Statement of Work

Tier 2 Test Equipment for EPA/NVFEL

Requirements, Functional Specifications, Performance Criteria, and Acceptance Tests

U. S. Environmental Protection Agency
National Vehicle and Fuels Emissions Laboratory
2565 Plymouth Road
Ann Arbor, Michigan 48105

Table of Contents

Table of Contents - Continued

Figures

Appendices

Statement of Work
Tier 2 Sampling, Measurement and Control Systems for EPA/NVFEL

1.0 Overview and General Requirements

This section provides an overview of the scope of the project and general requirements of the equipment being procured. Specific references, which provide important technical information or guidance, are listed in Section 1.1. Where noted, the requirements of some documents are incorporated by reference as requirements of this Statement of Work. Background information is presented in Section 1.2. A general description of the equipment covered by this Statement of Work, and associated requirements, is presented in Section 1.3. Other general requirements are covered in the balance of Section 1, including requirements for project management.

Contract deliverables and specific requirements are addressed in detail in subsequent sections of the Statement of Work.

Definitions of the acronyms used in this document are provided in the Appendix A.

1.1 References

1.1.1 Code of Federal Regulations 40 CFR, Subchapter C, Part 86 "Control of Emissions From New and In-Use Highway Vehicles and Engines," Subparts B, M, N, R, S

1.1.2 Code of Federal Regulations 40 CFR, Subchapter Q, Part 600, "Fuel Economy of Motor Vehicles"

1.1.3 Code of Federal Regulations 29 CFR Part 1910 "Occupational Safety and Health Standards"
All CFR materials may be found at http://www.access.gpo.gov/ecfr/

1.1.4 ISO DIS 17025 - General Requirements for the Competence of Testing and Calibration Laboratories
(www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=30239)

1.1.5 NFPA 70, National Electrical Code
(www.nfpa.org)

All references shall be the most current available as of the date of this contract solicitation.

1.2 Background

1.2.1 As part of the Clean Air Act and its Amendments, a variety of new emissions regulations have been implemented for vehicles and engines. Tier 2, NMOG, ULEV, OBD II on-board diagnostics, and Supplemental FTP are a few examples of test changes that require sophisticated and adaptable emission measurement systems. The EPA NVFEL has undertaken a comprehensive program to implement new and refined test systems to enhance the capabilities to conduct low level emissions testing, of the highest precision and accuracy, on a broad range of vehicles.

This document describes the engineering and operational requirements for measurement systems that will be required for implementing these enhanced capabilities. The equipment implementation described in this document is comprised of two complete measurement systems for two separate chassis test sites at the NVFEL, D329 and D005, and a partial upgrade of the existing measurement system for a third chassis test site, D002. These measurement
systems shall be used to evaluate both regulated emissions and currently unregulated emissions from spark ignition motor vehicles operating in a variety of ambient conditions and on a variety of fuels including those currently considered as "alternative". This specification addresses requirements to optimize the measurement of emissions at Tier 2 levels.

1.2.2 All general requirements listed in this Statement of Work apply to all three systems.

1.2.3 Reserved

1.2.4 For the equipment specified, the contractor shall have total system responsibility,
which shall include all phases of the project, design/configuration, assembly, integration, quality assurance, delivery to EPA-NVFEL, installation, calibration, commissioning, acceptance testing, documentation and training of EPA staff. The contractor shall be responsible for documenting measurement traceability and system acceptance in a manner suitable for audit to ISO standards.

1.3 General Description of Test Sites and Measurement System Requirements

1.3.1 **D329 Light/Medium Duty, FWD/RWD/4WD Test Site Overview**

This will be a new test site at NVFEL, intended to provide a wide range of test capabilities. It will house a medium duty / 4 wheel drive dynamometer intended to test a wide range of vehicles with from

1000 to 14,000 pounds of simulated inertia, with single or dual drive axles, fueled by gasoline, oxygenated fuels, alcohol fuels, gaseous fuels and diesel or other high-cetane fuels. The measurement system shall support protocols such as Tier2 level FTP, US06, SC03 (simulated), HFET and others.

The core requirement of this contract shall be to configure, build and implement a complete sampling and measurement system for this test site. This system shall provide for test sequencing and control, exhaust sampling and analysis, data acquisition and data analysis, processing and file transfer, along with a variety of tools for maintenance calibration and support activities. The system shall provide both CFV-CVS and Bag Mini-Diluter sampling for regulated gaseous emissions, as well as aldehyde and particulate sampling for all fuels, and alcohol sampling via impinger. The associated analytical system shall provide for direct on-site analysis of Carbon Monoxide, Carbon Dioxide, Hydrocarbon, Methane, Oxides of Nitrogen (NOx), Methanol, Ethanol and Formaldehyde.

The dynamometer and video driver's aide equipment for this will be provided by others, but integration with these subsystems shall be included as part of the work described in this Statement of Work. Dynamometer and Driver's Aide interface requirements are outlined in Appendices to this Statement of Work.

The contractor shall deliver a system capable of the measurement, calculation, and reporting of the mass emissions from motor vehicles in accordance with the emissions standards and regulations referenced in Section 1.1 and the specifications contained herein. The system shall provide the necessary software to calculate the emissions from both the CVS and BMD systems.

An overview of the major components/functions to be provided as part of the measurement system provided by this contract, is as follows:

<u>Test-Control, Data Acquisition and Processing System (TDAP)</u>

This system of computers, logic controllers, displays and associated devices shall integrate and control operation of the sampling and analytical systems and collect all data directly related to processing an emissions test. It shall provide a clear, simple and logical user interface. It shall perform associated quality control of the testing process and provide rigorous documentation associated with quality control and traceability. It shall provide automation of most tasks associated with testing and support activities. It shall provide for preliminary processing, reporting and file transfer of test data, and provide a range of flexible data analysis tools to support special investigations and trouble shooting. The system shall integrate with the EPA/NVFEL-provided video drivers system, described in Appendix B, and the dynamometer control system, as described in Appendix E.

The contractor shall integrate their measurement system with a separate EPA supplied network interface computer (IFC), described in Appendix C. The TDAP-IFC integration shall provide a direct and controlled communication link between the test system and the EPA/NVFEL Laboratory Network System (LNS) via a network switch. A block diagram showing the desired test site / LNS architecture may be found in Figure 1.

Low Level Gaseous Exhaust Emissions Analytical Systems

The contractor shall provide two separate analytical systems to measure regulated gaseous emissions. One system will be targeted for measuring emissions from vehicles fueled by gasoline and related fuels and the second system for vehicles fueled by diesel and related fuels. These systems must be capable of making highly accurate and precise measurements at very low levels of emissions from vehicles compliant with the Tier 2 rule and other similar regulations. The gasoline analytical system shall also include provision for the direct measurement of ethanol and formaldehyde.

CVS Sampling Systems/Dilution Tunnels

The measurement system shall provide for emissions collection from any vehicle via separate collection systems for vehicles fueled by gasoline and related fuels and for vehicles fueled by diesel and related fuels. The CVS system shall allow for a wide range of total bulk stream flow via a system of selectable sonic flow nozzles and shall provide for direct measurement of dilution air. The dilution tunnel shall be designed to minimize particulate loss due to impaction and thermophoresis. The sampling system shall include separate sample controllers for particulate collection and the collection of exhaust compounds via impingers and sample cartridges.

Bag Mini-Diluter Sampling System

The D329 measurement system shall include a raw exhaust, constant-dilution proportional flow sample collection system, commonly referred to as a Bag Mini-Diluter system. This system shall be comprised of a direct exhaust flow measurement device (commonly referred to as EFMS or DEVM), a constant dilution, proportional bag-filling system, all related dedicated control hardware and software, and a zero air purification system

1.3.2 **D005 Light Duty Test Site (OPTION 1)**

This test site houses an existing 48” roll electric dynamometer and older test control, data acquisition and sampling and analytical systems. The contractor shall provide a sampleing and measurement system to replace the existing cell control, data acquisition and sampling and analytical systems at this site. This site shall be used to test light duty cars and trucks at the lowest levels of Tier 2 fueled by gasoline and similar fuels. The existing dynamometer and EPA video driver's aide shall be utilized. This measurement system will not include requirements to sample and measure particulate matter, oxygenates, aldehyde or alcohol. An overview of the major requirements/functions for this measurement system is as follows:

Test-Control, Data Acquisition and Processing System (TDAP)

The provided system shall parallel the system referenced in the D329 except that the functionality will be reduced to those required by the more limited scope of testing to be accomplished at the D005 site.

Low Level Gaseous Exhaust Emissions Analytical System

This system shall parallel the gasoline analysis system referenced in respect to D329 above. No diesel analysis will be required for D005.

CVS Sampling Systems/Dilution Tunnels

This system shall parallel the gasoline sampling system referenced in respect to D329 above except that the total flow requirement is somewhat reduced by eliminating one flow nozzle and reducing the blower size accordingly. In addition this system does not include any requirements directly related to sampling particulate matter from the exhaust stream, or any provision for impinger and cartridge sampling.

Bag Mini-Diluter Sampling System

This system shall be identical to system referenced in 1.3.1 above, with the exception of the zero-air purification system and certain details related to physical installation.

1.3.3 **D002 Light Duty Test Site (OPTION 2)**

This site houses an existing 48 inch roll electric dynamometer as well as a low level emissions measurement system described in Appendix D. This measurement system is approximately two (2) years old and contains many of the features required for the D005 system described above, with the exception of the bag mini-diluter sampling system. The contractor shall provide for the full integration of a bag mini-diluter sampling system, as provided in the D005 system, with the existing D002 measurement system.

1.4 Safety, Health and Environmental Provisions

1.4.1 Providing for a safe working environment is the highest priority in all EPA equipment purchases and installation activity. The contractor shall abide and comply with all building and safety codes specified by ASME, AISC, NEC, OSHA, BOCA, and NFPA wherever they might apply, to create an intrinsically safe system and work environment.

1.4.2 Significant risk factors such as noise, ventilation of toxic gases, heated surfaces, electrical shock, and safety interlocks to prevent accidental errors shall be considered, and control measures to ensure the safety of operations and maintenance personnel shall be implemented wherever feasible.

1.4.3 As required by OSHA, all equipment shall be designed to provide for straightforward lockout protection in accordance with OSHA regulations. Written lockout instructions, in hard copy and electronic formats, shall be provided as part of the "as installed" documentation package.

1.4.4 Noise or vibration from equipment installed as part of this contract shall not penetrate the building or cause adverse affects on other equipment in the facility. Sound dampening/suppression devices and/or materials shall be installed as needed to limit noise levels to 60db at 10 feet from any devices to be located outside of the test cell, 75db at 10 feet for devices located in the test cell. Devices to be located in the control room must meet the 60db requirement.

1.4.5 The contractor shall consider energy efficiency in all component selection, system design and operational strategies. Energy efficient equipment, such as those with the "Energy Star" designation shall be utilized when possible.

1.4.6 The contractor shall consider the minimization of the generation and release of harmful materials to the environment in all component selection, system design, and operational strategies and installation requirements.

1.4.7 Reserved

1.4.8 The contractor shall provide the NVFEL Project Officer with a complete list of chemicals to be utilized during installation and commissioning operations at NVFEL, and their associated Material Safety Data Sheets (MSDS), at least four weeks prior to system installation.

1.5 Quality Provisions

1.5.1 As part of this contract, the EPA is purchasing measurement systems that will produce data of highest precision and accuracy with a high level of certainty, in a manner that can be comprehensively demonstrated and documented. All equipment and all functions performed by measurement systems must be in accordance with the vehicle emissions testing and fuel economy-testing requirements of the Code of Federal Regulations and all other codes, standards, practices, etc. included by reference therein or elsewhere in this document.

1.5.2 The contractor shall carefully consider all requirements referenced in this Statement of Work, and all other documents incorporated by reference, and design a complete and efficient quality strategy for ensuring that all systems delivered as part of this contract meet those requirements, and will continue to meet them on an on-going basis. This strategy is expected to include automated pre-test and post-test checks, diagnostic checks, real-time condition monitoring and exception reporting, routine maintenance activities, mistake-proofing and full documentation of NIST traceability where applicable.

1.5.3 All documentation and system instructional, alarm and warning messages shall be delivered in a clear, concise manner, in plain English, with a minimum of technical jargon.

1.5.4 Systems delivered under this contract are expected to support compliance with ISO 9000 series standards, and ISO DIS 17025, in a complete and efficient manner.

1.5.5 The contractor shall provide automated systems which monitor and track long term performance of key instrument operating parameter such as response, flow, temperature drift, etc., to provide early warning of failure or significant change in operating performance.

1.5.6 The contractor shall deliver systems which provide for automated archiving of active as well as previous, or inactive calibration and verification data for all provided instrumentation.

1.5.7 The contractor shall provide systems for the automated verification and calibration of all analog signal conditioning hardware delivered as part of this contract.

1.5.8 Within the context of this Statement of Work the word “calibration” shall mean:

Calibration - set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or reference material, and the corresponding values realized by standards. (International Vocabulary of Basic and General Terms in Metrology (VIM; 1993) definition)

Furthermore "calibration" shall mean a defined set of actions which produce a permanent record of the relation of instrument response to standards.

Calibration shall NOT refer to the routine adjustment of instrument offset and gain through the use of "zero and span" materials.

1.5.9 The delivered systems shall not update any calibration data or other constants that affect emission results without first explicitly verifying via a dialog box that the action should occur. If the update is affirmed, the update shall be implemented immediately without having to reload any portion of the system or take other further action of any kind.

The update verification dialog box shall prompt for an operator ID and provide for operator comments, if any. These updates shall be permanently and centrally documented in an electronic file which stores the old information and new information as part of a clear audit trail. The update documentation file shall be readily accessible, printable, archiveable, and copyable, and shall provide for additional comments, which may be added at any time at the highest level of password protection.

This update function shall be available both "real-time," such as immediately following a calibration procedure, or at a later time, and shall include the option for additional control through the use of a special entry code. Activation of the access code option shall only restrict actual change implementation. Changes may be stored as "pending" for later implementation. All pending changes shall be easily retrievable for later authorization via a screen-viewable and printable listing. Only one calibration for any device and range shall be allowed to be "pending" at one time.

At a minimum, each record in the documentation file shall include a unique serial number, a clear description of the action taken, with change time and date, the resulting data change, operator ID, comments, and verification code (if any).

1.6 Operational Efficiency

1.6.1 The EPA seeks to maximize value in all its testing operations, and expects the measurement systems delivered as part of this contract to demonstrate a high level of efficiency. The contractor shall consider operational efficiency in all aspects of the design and functioning of these measurement systems. As a simple example, during an automated protocol for CVS verification, it is expected that the system would automatically zero and span the hydrocarbon analyzer while simultaneously acquiring samples, thus internalizing one operation to another and minimizing the total time required for the entire operation. Other examples would be to provide for unattended operation of certain lengthy procedures such as gas analyzer calibrations or computer system back-ups.

1.6.2 The equipment shall be designed and configured to function satisfactorily for extended periods on a continuous basis, except for scheduled maintenance. Scheduled maintenance should be minimized.

1.6.3 The measurement system shall be designed and configured to facilitate safe, one-person test operation.

1.6.4 All components of the systems specified in this contract must be free of any date-based obsolescence (e.g. "Y2K") problem that would impair operational efficiency or veracity through the year 2050.

1.7 Electrical Requirements

1.7.1 Reserved

1.7.2 Electrical power shall be provided by EPA to within 50 feet of the point of use.

The EPA will provide the following 3 types of power panels, as required, within 50 feet of the point of use. Motor and other noisy loads will not be allowed on the clean power grid.

208V/120V, 1 phase, 60 Hz, utility grade power

480V/277V, 3 phase, 60 Hz, utility grade power

208V/120V, 1 phase, 60 Hz, clean power

1.7.3 All equipment shall be installed in accordance with the 2002 edition of NFPA 70, National Electrical Code and required local codes.

1.7.4 Equipment design and installation shall permit operation in compliance with Occupational Safety & Health Administration (OSHA) Standards Part Number 1910. Electrical equipment shall comply with Part 1910 Subpart S.

1.7.5 Equipment design and installation shall be in compliance with 2000 edition of NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces.

1.7.6 Equipment design and installation shall provide energy-isolating devices required for equipment operators to follow the OSHA rule on the Control of Hazardous Energy (Lockout/Tagout) of Title 29 of the Code of Federal Regulations (29 CFR) Part 1910.147.

1.7.7 All electrical cables shall be isolated from gas lines.

1.7.8 The contractor is responsible for providing and installation of all power circuits disconnects, transformers, circuit protection devices, and associated hardware required to interface with EPA provided power panels of paragraph 1.7.2.

1.7.9 All power receptacles shall be heavy duty, industrial grade. Spare power receptacles for future upgrades and maintenance shall be provided.

1.7.10 Clean/uninterruptible power outlets shall be clearly marked and in a color selected by the project officer.

1.7.11 Clean/uninterruptible power outlets shall be isolated from utility grade power systems and installed in accordance with the principles of IEEE Std 1100.

1.7.12 All cables external to equipment cabinets with voltages over 50V (AC or DC) shall be run in metal conduit or other EPA approved raceway.

1.7.13 Control and signal cables shall be isolated from power cables. All signal cabling shall not be adversely affected due to capacitive or inductive interference.

1.7.14 All Control and signal cables/wires shall be permanently labeled with to/from and signal/function name information that corresponds with the provided electrical schematic.

1.7.15 All crimp or compression type connections shall use only the component manufacturer's approved crimp tools and shall follow the component manufacturer's termination instructions.

1.7.16 Discrete digital input/output (I/O) channels shall be 0 to 5 volt TTL level and shall be optically isolated from their source.

1.7.17 Digital I/O communications channels shall conform to recognized industry standards such as IEEE 802, RS232, RS485, IEEE 488, IEEE 1394, or USB.

1.7.18 Analog I/O shall support both 0 to 5 VDC and 0 to 10 VDC and thermocouple inputs.

1.7.19 The contractor shall provide complete electrical schematics and wire lists in their final documentation package.

1.8 Project Management and Schedule of Deliverables

1.8.1 The contractor shall comprehensively manage the project to ensure on-time completion and efficient interaction with EPA during all phases of the project. The contractor shall develop a preliminary project plan for review with EPA at a project kick off meeting. The Project Management plan shall indicate the contractor's project manager, key personnel and contact information, the project time line, and sample formats for meeting minutes, progress reports and open issue tracking. Based on the outcome of the Project Kickoff meeting, the contractor shall deliver a complete project management plan as indicated on the Schedule of Deliverables for this contract.

1.8.2 The project management plan should also include the submissions, milestones and events to be completed no later than the dates indicated on the Schedule of Deliverables. Alternate dates for intermediate milestones may be proposed at the Project Kickoff meeting, but all modifications must be approved by the EPA Project Officer.

1.8.3 Full measurement system acceptability shall be demonstrated during the off-site acceptance process. Equipment shipment to EPA shall not occur until this requirement is met. The contractor shall have responsibility for preparing a report thoroughly documenting all quality assurance activities and acceptance results.

1.8.4 The contractor shall provide on-site supervision of all installation, commissioning and acceptance activities. All contractor personnel shall receive 1-hour briefing by EPA personnel on specific safety and security issues. All contractor personnel and subcontractor personnel must comply with EPA/NVFEL safety and security measures while working at NVFEL.

2.0 D329 Measurement System Requirements

2.1 Measurement System Layout and Configuration

2.1.1 The contractor shall design a layout for the measurement system that optimally fulfills the various requirements of this Statement of Work, based on the nominal test site layout shown in Figure 2.

2.2 Test-Control, Data Acquisition and Processing System (TDAP) Functions

2.2.1 This system of computers, logic controllers, displays and associated devices, as configured by the supplier shall integrate and control operation of the sampling and analytical systems and collect all data directly related to processing an emissions test. It shall provide a clear, simple and logical user interface. It shall perform associated quality control of the testing process and provide rigorous documentation associated with quality control and traceability. TDAP shall provide automation of most tasks associated with testing and support activities. It shall provide for preliminary processing, reporting and file transfer of test data and vehicle information data and provide a range of flexible data analysis tools to support special investigations and trouble shooting.

2.2.2 TDAP may consist of a range of hardware and software components depending on the configuration and functioning of the contractor's proprietary test systems, provided the automation requirements contained in this Statement of Work are met.

2.2.3 TDAP computer system(s) shall utilize color and real-time graphics and shall provide for a multiple window operating system.

2.2.4 All TDAP operating system software, control software and parameters, and data acquisition interfaces shall be stored and accessed using the most up to date commercially available standard microcomputer hardware and most up to date Commercial Off the Shelf (COTS) components where possible. LCD flat-panel monitors shall be used for standard displays.

2.2.5 The computer interface(s) shall be designed such that personnel without specialized computer experience will be able to operate the control system and the peripheral units, including the input of parameter changes, with minimal basic system training.

2.2.6 The test process control software shall utilize a graphical user interface and provide for user definition, customization and modification of variables, limit tables, alarm functions and test process scripts. Variables shall be definable as Boolean, integer, or floating point with at least 6 significant digits stored plus the exponent, (±x.xxxxxE±nn). All variables (system and user defined) and their associated definitions and settings shall be viewable on screen and printable as a list showing the variable descriptive information. At a minimum variable lists shall be presented in alphabetic order, or readily sortable. See Appendix C for general file transfer and interfacing requirements.

2.2.7 The system shall also support the definition of calculated variables that are derived from combinations of other user-defined variables. These variables shall be usable in all scripts without redefinition.

2.2.8 The system shall utilize a command structure and scripting that is modular in the sense that multiple scripts can call one routine to execute a specific function. Hence, global updates to all scripts are made by changing the parameters of the variable definition in one location rather than in every script.

2.2.9 The system shall provide for automated context and syntax checking of user-defined scripts and alterations. Diagnostic error messages and help comments shall be provided to the user. All scripts shall be viewable and printable.

2.2.10 Any window on a TDAP display screen shall be printable to the system laser printer and shall be automatically scaled to fit the page.

2.2.11 The current date and time, in any format that contains month, day, year, hour, minute, and second, shall be contained on all printed images of screens, files, or reports from the system. The system name from which the output was generated shall also be contained on the printout.

2.2.12 TDAP shall provide for all data acquisition required for all functions related to the performance of this Statement of Work including:

a All pressures required for calculations and for operational monitoring and quality control

b All temperatures required for calculations and for operational monitoring and quality control

c All flowrates required for calculations and for operational monitoring and quality control

d All concentrations required for calculations and for operational monitoring and

quality control
e Test cell humidity and barometric pressure

f All digital (on/off) or frequency data required for process control,operational monitoring and quality control

g Engine Speed Tachometer (RPM, 0-10VDC input user configurable scaling)

h Current from hybrid drive energy storage device (Amps, 0-10 VDC input user configurable scaling)

i Current to hybrid drive energy storage device (Amps, 0-10 VDC input - user configurable scaling)

j Hybrid drive energy storage device voltage (Volts, 0-10 VDC input - user configurable scaling)

k Instantaneous fuel consumption (0-10 VDC input - user configurable scaling and units)

l Minimum 8 Spare Channels (0-10 VDC input - user configurable scaling and units)

m Minimum 8 Spare Channels (Frequency 100KHz - user configurable scaling and units)

n Minimum 8 Spare Channels (Temperature degrees Centigrade, J-type thermocouple)

o Minimum 8 Spare Channels (Temperature degrees Centigrade, K-type thermocouple)

2.2.13 Data shall be acquired at 20 Hz and stored and made available at 20 Hz and 1 Hz. One Hz data shall be the 1-second average of the 20 Hz data.

2.2.14 TDAP shall also include hardware and implemented procedures for the following functions:Complete system backup & restore from tape (system bootable from tape).
System configuration, parameters backup & restore.

Test Data backup & restore (to be done daily).
File trimming based on creation date or modification date
Complete power-down and power-up procedure sequence.

2.2.15 TDAP shall include a color laser printer:

HP LaserJet 5500DN (Duplex and network) or
HP LaserJet 8550DN (Duplex and network)

or current equivalent model

2.2.16 All access to TDAP shall be password protected as follows:

Level 0 (Base Maintenance)- Routine system maintenance functions only, to include automated backup and file trimming procedures

Level 1 (Operator) - The ability to run defined tests, view active channel displays, read (but not change) test scripts, definitions, variable names and other related files, view and print reports and utilize interactive functions for analyzing data.

Level 2 (Maintenance/Repair) - All level 1 plus the ability to perform diagnostics, routine maintenance and trouble shooting functions.

Level 3 (Administrator/Engineering) - Full system access, all level 2 plus the ability to edit test scripts, channel configurations, bit maps, tables, user-defined variables, alarm actions, report definitions, and system configuration and other administrative functions

TDAP shall include a selectable option, configuraable at Level 3, to automatically log-out after a predefined duration of system inactivity.

2.2.17 The contractor shall be responsible for the integration of specific equipment provided by others with TDAP. This equipment will consist of the EPA Video Drivers Aid, dynamometer control computer, and EPA interface computer (IFC) as specified below.

2.2.18 For the D329 system, TDAP shall interface with the electric dynamometer to enable automatic transfer of vehicle identification, test weight and road load coefficients and test performance data, and to provide for basic control and monitoring of test execution. The interface specification is defined in Appendix E.

2.2.19 The contractor shall integrate their measurement system with a separate EPA supplied network interface computer (IFC), described in Appendix C. The TDAP-IFC integration shall provide a direct and controlled communication link between the test system and the EPA/NFVEL Laboratory Network System (LNS) via a network switch. A block diagram showing the desired test site / LNS architecture may be found in Figure 1.

The purpose of the IFC is to provide a uniform, controlled and restricted interface between laboratory instrumentation and the Laboratory Network System. The use of IFCs at NVFEL allows for isolation of instrumentation from other extraneous laboratory and network activity. The IFC shall function only to provide for the passing of files between the test site system (TDAP) and LNS, as well as other LNS-based operations to be determined and defined by EPA.

2.2.20 TDAP shall integrate with the EPA-provided Video Driver's Aid system (VDA). The VDA is described, and the interface requirements are listed, in Appendix B .

2.2.21 The VDA shall serve as the master test sequencer for all driving events. EPA systems will maintain the database of drive traces and shift schedules for VDA. The VDA system will display the driver's trace and relevant run-time messages to the driver. VDA will monitor signals from the driver to indicate vehicle operation status (crank, stall, driving, engine stop, etc.). Digital signals will be provided to TDAP to indicate individual sample collection periods and will relay vehicle operation status as indicated by the driver. TDAP will perform electronic hand shaking with the VDA to agree that all systems are ready, or not ready, for a test to begin. TDAP will respond to the digital signals as described in Appendix B.

2.2.22 TDAP shall issue critical system status and critical alarm messages to the driver via VDA per the communication protocol outlined in Appendix B.

Optionally, the contractor may include a remote color LCD message unit to be mounted on the EPA-provided VDA boom. This unit shall measure approximately 6"x8"x1" and weigh less than 1.5 pounds. The purpose of this display is to provide for simple text messaging from TDAP for communicating system status and critical alarms to the vehicle driver in place of issuing those messages via VDA.

For purposes of this contract this display function will be referred to as the Remote Message Display, or RMD, and shall be taken to mean either the issuing of text messages to the VDA or separate hardware display.

2.2.23 At a minimum, TDAP shall provide the following additional implemented, automated processes.

For each process TDAP shall provide for all relevant operator interface, data acquisition, data storage and reporting and operational quality control.

a) Federal Test Procedure (UDDS/HDDS) - (3 phase)
b) Federal Test Procedure (UDDS/HDDS) (4 phase)

This test is identical to the three phase except that it consists of two repeat LA-4 cycles. Results are calculated with the actual hot-stabilized phase result instead of setting the hot-stabilized phase result equal to the cold stabilized phase. This test is used primarily in the testing of hybrid vehicles as it theoretically provides a better opportunity for the hybrid energy storage device to return to the start-of-test charge condition.

c) HFET

d) USO6

e) SCO3 (simulated)

f) NYCC

g) IM240

h) Japan Cycle

i) REPTRUK 2-phase

This is a two phase test, similar in operational respects to the LA4 except that the phase lengths are 310 seconds and 320 seconds with nominal driving distances of 2.65 and 3.52 miles. The first phase consists of driving conditions representative of the LA4 and the second phase consists of driving conditions similar to the Highway Fuel Economy Test. This test is utilized by EPA as part of a structured laboratory quality control program.

j) TIER 2 Blank Test/ Exhaust Simulator Test

This function shall mimic the performance of a Federal Test Procedure (UDDS/HDDS) - (3 phase) *CVS test without a vehicle actually being run. For this test all irrelevant warnings shall be suppressed, drive distances assumed to* *nominal and dilution factor set to 10. The purpose of Blank Test is to provide an indicator of system hang-up. The purpose of Simulator Test is to assure accurate system functioning and measurement through the measured recovery of a known mass of dynamically injected reference material. For both tests, both sample concentration and mass emission shall be reported for each test phase*

k) Gas Analyzer Calibration with Automatic Span and Mid-Range Checking of the Candidate Curve (Ref CFR)

l) Pressure Transducer Calibration/Verification

m) Temperature Channel Calibration /Verification

n) Auxiliary Channel Calibration/Verification

o) NOx Eff check

p) NOx Quench Check

q) CVS Verification by propane injection (both bomb and CFO methods)

r) BMD/Auxillary Sampler/CVS Verifications

This test will be conducted in a manner similar to a conventional CVS verification per the description found in 2.3.39.

s) CO2 and water interference check of CO analyzers

t) Determination of Methane Response of Total Hydrocarbon Analyzer

u) Determination of Generalized HC Species Response of Total Hydrocarbon Analyzer (Single Component)

This is to be performed in a manner equivalent to the methane response determination.

v) Determination of Oxygen Correction of Total Hydrocarbon Analyzer Response

w) Verfication/Calibration functions for all system flow-measurement devices

x) Instrument zero/span adjust, including zero/span alignment algorithms

y) Instrument zero/span verify, to include comparison of instrument-zero/span and overflow zero/span for the heated sample probes

z) Bag leak check routine (CVS and BMD)

aa) Bag Evac Only

bb) Bag evac-purge-evac

cc) External bag sample read (through remote bag port)

dd) Dilution air sample read

ee) CVS recommended flow calculator

This function shall recommend the minimum CVS flow that will prevent condensation in the sample system, based on fuel type, driving cycle, vehicle parameters and other factors, as deemed appropriate by the contractor.

ff) Sample transport and measurement delay time determination/signal alignment tool

2.2.24 All vehicle test procedures shall include test configuration options as follows:

a. CVS sampling, BMD sampling or both
b. Bag sampling, Continuous dilute sampling or both
c. Particulate Matter sampling
d. Impinger sampling
e. Aldehyde sampling
f. Auxiliary Bag Sampling
g. Hybrid/electric vehicle energy management monitoring
h. Ambient temperature and humidity monitoring only
i. Auxiliary Data Collection only (user specified)

2.2.25 Pretest information files will be available via EPA-IFC for all vehicle tests per the description found in Appendix C. Additional time of test information will be required as follows:

a. Operator ID
b. Vehicle Mileage
c. Actual Fan Placement (code) Note: Requested fan placement should be displayed in the dialog box, above this line
d. Fan Placement Remarks
e. Test Set-up comments

All pretest information shall presented with an option to edit if needed.

2.2.26 TDAP shall prompt for the following Post-Test information:
Phase 1 Remarks
Phase 1 Data Header A
Phase 1 Data A
Phase 1 Data Header B
Phase 1 Data B
Phase 1 Data Header C
Phase 1 Data C
etc.
Phase 4 Data C

2.2.27 If the test just completed was a HFET, TDAP shall prompt for three dynamometer quick check coast down times (xx.xx seconds). TDAP shall calculate the average and range of these times and display the data on the screen and in the test report.

If the range of the three times exceeds 0.3 seconds, TDAP shall display a warning on the screen and on the test report, and prompt the operator if they want to repeat the test. If "yes" then allow the entry of three additional times, if "no" close the dialogue box. All coastdown data shall be shown on the test report.

2.2.28 If the test included particulate determination, TDAP shall allow for separate post test entry of pre-test and post-test filter weights and associated filter numbers. This entry process shall also allow for entry of "remarks."

2.2.29 All dialog boxes utilized for collecting Pre-Test and Post-Test information shall be easily modifiable to accommodate future information requirements. Such modifications shall result in the incorporation of new data into the test record.

2.2.30 For all operations, TDAP shall display run time information on the main display screen in logical, hierarchical manner. A real time, scalable display vs. time (both as a line and as a numerical value) of any variable in the system shall be available on screen during a test sequence. Available display screens shall include a "hot-soak timer" which prominently displays a countdown timer for any mid-test non-driving event. This screen shall appear on both the main display and RMD. For the FTP hot-soak period the display shall count down from -10 minutes, then up to +1 minutes. At +1 minutes a prominent message shall be shown on both the main display and RMD that the allowable soak time has been exceeded.

2.2.31 TDAP shall provide for the option of selecting/deselecting specific analyzers and selecting specific measurement ranges at time of test. If manually selected, the system shall not change the selections at time of measurement.

2.2.32 TDAP scripting and the design and fabrication of the measurement system bag filling hardware, flow path, and valve and pump control shall enable adaptations to standard test sequences, such as additional bags or changes in the bag filling and analysis sequences through TDAP configuration changes.

2.2.33 Sample bags shall be automatically evacuated, purged and evacuated prior to each automated test sequence. This system shall be configured to evac-purge-evac all eight bags in less than 5 minutes.

TDAP shall monitor sample bag status to ensure that bags are not improperly utilized. Bags shall not be utilized unless they have been purged, evacuated and are "ready." If a conflict is detected a dialog box shall appear with an appropriate message and give the option to override. TDAP shall also issue a fault message to the RMD, but no option to override will be given at the RMD.

2.2.34 Sample system/bag leak checking shall be a separate, stand-alone function and shall not be automatically performed for each test. This system shall be configured to evac-purge-evac-leak check all eight bags in less than six minutes. These functions shall be fully automated and include user selection for checking each bag singularly and in any combination. The purge/evac/leak check process and criteria shall be definable and changeable. A specific purge/evac process shall be stored as a subroutine, which can be used by a test process script.

The leak check shall be based on vacuum decay of individual sample bags, utilizing a high-resolution transducer(s). The starting vacuum shall nominally be 20 inches of Mercury. The bag leak check shall be considered to be acceptable if the observed vacuum decay is less than 2 inches of Mercury in 1 minute.

2.2.35 Sample pumps shall be automatically switched off at the termination of a sample event.

2.2.36 TDAP shall monitor all critical sub-systems included in this contract at the initiation of a test, and during a test. If any subsystem is not in "run" status at the beginning of the test, the test would not be allowed to start without a manual override command. If a run status fault is detected at any point in the test sequence, a warning or alarm message to that effect is displayed on the main display and the RMD.

To accomplish this monitoring function, the system shall utilize easily configurable and modifiable tables, specific to the operation being performed, to allow for easy designation of exceptional conditions as critical or non-critical. Non-critical sub-systems should be distinguishable from critical sub-systems any such warnings or alarm messages. Only critical messages shall be displayed on the RMD. Parameter tables shall be printable for documentation purposes.

Exceptional or non-nominal events or conditions shall be logged in files for post test exporting and reporting.

2.2.37 TDAP shall monitor dynamometer status at the initiation of a test, and during a test. If the dynamometer is in run status no action is taken. If the dynamometer is not in run status at any point in the test sequence, an alarm message to that effect is displayed on the main display and the RMD.

2.2.38 TDAP shall include a digital input for monitoring an EPA-facility test cell safety string, 1=normal, 0=alarm. TDAP shall provide for activating and deactivating this monitoring function, and modifying alarm actions within the system administrator environment. In the event that the system detects the alarm state, TDAP is to cause the following events to occur:

The message "Facility Alarm!" shall be displayed on the main terminal and RMD.

After 5 seconds the system shall execute a shutdown sequence that will shut off CVS blowers, sample pumps and gas solenoid valves.

The sequence shall be programmed in an easily modifiable fashion similar to a test script.

2.2.39 TDAP shall monitor the CVS system for non-choke or abnormal flow in the main CFV or in the sample CFV system and display an appropriate alarm message on the main display and RMD. Choke flow monitoring shall be in accordance with 40 CFR 86.119-90, as amended by publication in the Federal Register February 18, 2000 and restated here.

(8) Calculation of a parameter for monitoring sonic flow in the CFV during exhaust emissions tests:
Option 1. (A) CFV pressure ratio. Based upon the calibration data selected to meet the criteria for paragraphs (d)(7) (iv) and (v) of this section, in which Kv is constant, select the data values associated with the calibration point with the lowest absolute venturi inlet pressure. With this set of calibration data, calculated the following CFV pressure ratio limit, Prratio-lim:

$$Pr_{ratio\text{-}lim} = P_{out\text{-}cal}/P_{in\text{-}cal}$$

Where:

Pin-cal = Venturi inlet pressure (PPI in absolute pressure units), and

Pout-cal = Venturi outlet pressure (PPO in absolute pressure units), measured at the exit of the venturi diffuser outlet.

(B) The venturi pressure ratio (Prratio-i) during all emissions tests must be less than, or equal to, the calibration pressure ratio limit (Prratio-lim) derived from the CFV calibration data, such that:

$$P_{out\text{-}i}/P_{in\text{-}i} = Pr_{ratio\text{-}i} \leq Pr_{ratio\text{-}lim}$$

Where:
Pin-i and Pout-i are the venturi inlet and outlet pressures, in absolute pressure units, at each i-th interval during the emissions test.

2.2.40 TDAP shall monitor critical operating parameters during an automated process to ensure the integrity and quality of the process. These parameters shall be monitored against easily configurable and modifiable alarm tables specific to the operation being performed. Parameter tables shall be printable for documentation purposes.

Based on these limits, the system shall issue warning messages on the main display, and in some cases on the VDA/RMD as warranted, if the quality of the procedure is likely to compromised or if component failure may be imminent. The alarm tables shall include a designation as to whether or not to also display an associated message to the driver via the remote messaging function. These tables shall also contain the message text.

The result of the quality monitoring process, including all warnings and exceptions, shall be stored as part of the test data and summarized on a Quality Control Report.

2.2.41 Additional minimum requirements for the monitoring function and report, are found in Appendix F. The quality monitoring function shall also include any other parameters made critical to the quality and validity of the test by contractor-specific design.

2.2.42 A detailed specification of run time quality control shall be submitted to EPA for approval as described in the Project Management Section of this Statement of Work.

2.2.43 All automated test, calibration and verification functions shall include an option to produce a summary report.

2.2.44 For all reports, pertinent header information shall be presented on each page, sufficient to uniquely identify that each page is part of the same test report. All pages, of all reports, related to specific vehicle tests shall contain the EPA test number for that test. Vehicle test reports shall be similar in format and layout to the report shown in Appendix G.

2.2.45 All report pages shall be labeled with the current page number and the total number of pages.

2.2.46 All reports and computer records produced to document measurement instrument calibration/verification shall minimally contain the following information:

Name of Operation, Pertinent references
Date, Time, Operator

EPA Test Site Designation
Identification of devices and standards utilized
Data related to pertinent conditions, such as pressure, temperature, humidity
All data directly related to the operation conducted
Summarized data related to outcome such as coefficients, offsets, efficiencies, both “as found” and “as calibrated,” where applicable
Other pertinent statistics to indicate quality of outcome such as regressions statistics and other summary statistics
Text-type notes and observations
Pass/Fail indications and Accept or Reject indications, where aplicable
Units identified for all data

2.2.47 For all reports, pertinent header information shall be presented on each page, sufficient to uniquely identify that each page is part of the same report. All report pages shall be labeled with the current page number and the total number of pages.

2.2.48 All report layout and content shall be approved by the EPA project officer, as indicated in the Project Management Requirements.

2.3 CVS Sampling Systems/Dilution Tunnels

2.3.1. The CVS system shall provide for emissions collection from any vehicle via separate sample collection systems for vehicles fueled by gasoline, and related fuels, and for vehicles fueled by diesel, and related fuels. Gasoline and diesel systems may share common CVS system components if those components are located downstream of the last point of sample removal.

2.3.2. The CVS system shall allow for range of user selectable total bulk stream flows via a system of selectable sonic flow nozzles and shall provide for direct measurement of dilution air.

2.3.3. This system shall also be supplemented by an exhaust volume measurement device coupled with a Bag Mini-Diluter (BMD) for optimizing very low concentration measurements. The measurement system shall be designed such that both the BMD and CVS may operate independently or in series. When operating in series, CVS data shall be corrected for BMD sample removal.

2.3.4. Detailed functional and performance specifications for the sampling system are provided in later paragraphs. The contractor shall configure a system that meets these requirements in a manner that will provide adaptability for future needs. The overall sampling system shall facilitate potential future expansion, adaptation, and enhancement of exhaust sampling and analysis capabilities such as real-time FTIR measurements or real-time particulate measurements.

2.3.5. In addition to the gaseous emissions, the sampling system shall also incorporate separate dilution tunnels, secondary dilution tunnels, sample preconditioners, filter holders and particulate samplers to measure low level of particulate emissions from gasoline and diesel fueled vehicles. The dilution tunnels shall be designed to minimize particulate loss due to impaction and thermophorisis.

2.3.6. All major components shall be designed, fabricated and installed in such a manner as to facilitate safe, easy set-up and hook-up to a wide range of vehicles, by one person.

2.3.7. The vehicle exhaust dilution and transport system shall use smooth, clean, oil free stainless steel tubing, connectors and fittings, electropolished and chemically passivated with 10% nitric acid.

2.3.8. The assembled sampling system shall have the necessary components to isolate the sample tunnel for leak checking. The sample system shall be leak-tight, with a leak rate of less than 10 cfh at 5 inches H2O static pressure.

2.3.9. The CVS controller shall operate on 120 VAC connected from a single facility connection. If any required current exceeds 30 amps, that part of the system shall operate on 480 VAC, 3 phase. The wiring installed with the dilution air system, the sampling system control and the blower shall have three conductors for 120 VAC or four conductors including earth ground and three power lines for 480 VAC. The power distribution panel shall have interlocking manual circuit breakers and overload protection.

2.3.10. All measurement equipment shall use instrument quality power from a separate clean power circuit that will be provided by EPA. Pumps, ovens, heated lines, blowers and other non-critical electrical devices shall use normal utility power. Equipment to be connected to these power sources shall be isolated from each other in a manner that eliminates any interference or induced noise or voltage spikes

2.3.11. The CVS blower shall be located in a non-obstructive location and the flow shall be exhausted to the building exhaust system. Exact positioning requirements of the CVS blower shall be based on the information provided at the Project Kickoff Meeting.

2.3.12. The blower system shall be separate from the sampler unit. A duct shall be supplied between the sampler unit and the blowers and exhaust vent. The blower inlet/outlet piping shall be sized for pressure drops that assure adequate flow and configured for ease of maintenance, flexibility, and cleaning.

2.3.13. The blower shall be sized and rated to maintain the CFV/CFV's in choke or critical flow with a 30% excess flow capacity at rated suction. The blower motor shall operate on 480 VAC, 60 Hz, 3 phase, "Y". Electrical motors shall be equipped with magnetic starters and have a power factor greater than 0.90 and shall not contribute any EMF, RFI, or ground loop noise or interference.

2.3.14. The system shall provide a surge bleed for the blower as necessary and shall provide constant monitoring to assure choked flow is maintained. A sampler duct ahead of the CFV's shall provide multiple fittings for the sample extraction and bypass return/purge lines as well as the inlet pressure and temperature instrumentation.

2.3.15. Noise suppression shall be provided for the CVS blower to assure a noise level less than 75db at 10 feet distance. All connections to outlet ducting shall be by means of removable couplings. A flexible section of tubing shall be provided by the contractor to provide alignment, strain relief, and vibration isolation.

2.3.16. The CVS system shall include a dilution air measurement and control system which shall modulate the supply of temperature-controlled air to the full flow dilution pipe that will accept the raw exhaust.

The dilution air control system shall be able to maintain the dilution air temperature from ambient to 125°F, as a selectable test option.

The CVS system control static pressure boost to compensate for pipe losses and other system pressure drops to maintain tailpipe backpressure within limits of ± 1.0 H2O, at all flow rates for the FTP, HFET and similar tests, and ± 2.0 H2O for the US06, as measured at the tailpipe exit.

2.3.17. The inlet to the dilution air system shall include HEPA air filters of sufficient surface area to maintain sufficient flow and pressure drop performance for 6 months of continuous testing on a 10 hour/day, 5 day/week basis. HEPA filters shall be standard sized units, 24” x 24” x 12”. HEPA filters shall be mounted on a plenum assembly for easy removal and replacement. HEPA filter design shall have a minimum particle removal efficiency of 99.97% at 0.3 micron. Two sets of filters shall be furnished.

The system shall include monitoring of the pressure drop across the filter, with a warning message presented when appropriate.

2.3.18. The contractor supplied dilution air control system shall be configured so that it can be installed in a fixed location in the test cell with sufficient straight tubing ahead of the dilution flow measurement device for highly accurate measurement. The dilution air measurement device may be a subsonic venturi or utrasonic flow measurement device. This system shall have fast response RTD sensors (per CFR) for the measurement of temperature and pressure transducers to indicate the inlet conditions. Devices such as dampers and flow conditioners shall be used to stabilize the pressure and flow signals. They shall be designed in a manner that provides an inherent pneumatic response to the transient flow changes during the tests.

2.3.19. The CVS shall be able to accurately meter and totalize the dilution air flow rate, and the total dilute exhaust flow rate, to determine the total volume at standard conditions over each phase of the emissions test. Both the total dilution air and exhaust mixture standard volumes shall be provided for each test phase. The metering accuracy of the indicated total volumes of both the dilution air and dilute exhaust shall be accurate to $\pm$0.5%, traceable to NIST.

2.3.20. Sample lines shall be installed from the dilution air supply system and from the dilute exhaust sampling section to the CVS control unit. These lines shall minimize the sample exposure area and transport time and assure the integrity of the sample and shall be of minimum length, not to exceed 25 feet. No sample conditioning which could affect the sample composition shall occur in this section.

2.3.21. The ambient and dilute exhaust sample pumps shall be fixed displacement pumps that have the capacity to deliver the required flows and pressures (or vacuums) for the FTP sampling. All parts in contact with the sample gas shall be of stainless steel or Teflon. This pump shall have a pressure relief of 10 PSIG and a solenoid valve dump port for bypass mode to enhance flow characteristics and to prevent condensation.

2.3.22. All solenoid valves used in the CVS control unit shall be two-way valves, normally-closed, rated for continuous duty. They shall be of a design that has minimized dead volume and surface exposure to the sample and a pressure drop that prevents condensation of moisture in the sample.

2.3.23. Any exhaust sample filter in the gaseous sampling system shall be made of media that does not produce or absorb gases which would in any way affect the measurement accuracy of any of the devices utilized in the gaseous measurement system described in this Statement of Work. Filters shall provide a visual indicator of use and easy accessibility for replacement. The filter shall be protected so that its integrity is not effected when the sample pump is turned on or off.

2.3.24. Plumbing for the transfer of the dilute exhaust samples shall be primarily of 316 stainless steel, which shall be cleaned and treated for handling ultra low concentrations as necessary. Short lengths of steel braided Teflon tubing may be used on pump inlets and outlets for vibration isolation. The sampling system shall have all sample and transport lines sized for minimal surface exposure, minimal dead or dilution volumes, optimal transport time and minimal pressure drop. These lines shall be protected from cuts or leaks, and shall have stainless steel tube fittings. Automatic leak check capabilities shall be provided.

2.3.25. All sample flow rates shall be maintained as continuously proportional to the main dilute bulk-stream flow, within ±2.0% at all times. This requirement shall be continuously monitored during all testing operations. All flow measurements utilized in this determination shall have an accuracy and repeatability of 0.5%, traceable to NIST.

2.3.26. This proportionality constant can be changed from phase to phase, but must be stable throughout the phase. For example, a higher sample flow rate into the sample container may be needed for short test phases in order to have adequate integrated sample for analysis.

2.3.27. The CVS sampling system shall have two modes of control operation local (manual) mode and remote (automated) execution, selectable on the front panel and through the computer interface. The control screen shall clearly provide for display of all pertinent data and measurement parameters and for a flexible and adaptable operator and procedural interface. The test logic and valve selection control shall be programmable from the control computer menus or selection screens, and shall be capable of manual selection or executable as an automated test sequence.

2.3.28. The CVS shall provide for local control of the following functions at the front panel. Local control means that the function can be selected and controlled by the operator. This could be done by a button or switch, or a computer interface of a virtual button that can be activated by mouse, touch, or menu selection. This control panel shall include but not be limited to the following functions

Power On/Off
Blower On/Off - CVS main blower
Blower On/Off - dilution air control system (tailpipe backpressure control)
Local and automatic control mode selection

2.3.29. For metering of diluted exhaust gas the CVS shall utilize four selectable CFVs - 250, 350, 500, and 700 scfm (68 °F and 760 mm Hg) flow rates. All possible combinations of flows, from 250 to 1800 scfm, shall be available through simple set-up procedures within TDAP. The flow rate selection valves shall be leak-tight and shall enable automated switching of flow rates in less than 2 seconds.

2.3.30. The venturi shall be removable by one person for cleaning or replacement with an alternate size in less than 30 minutes. The inlet coupling shall provide a reliable leak free connector. The contractor shall provide a straightforward procedure to verify the absence of leaks in the selection valves and couplers.

2.3.31. The bulk stream venturi internal surface shall be toroidally shaped and finished in accordance with the latest accepted engineering practices (i.e. ASME, ANSI) for dynamic fluid meters.

2.3.32. The bulk stream venturi shall receive a NIST traceable calibration with an uncertainty of 0.5% or better, prior to acceptance. The C1 value shall be calculated and reported in the associated calibration report. The critical flow rate shall be obtained when 4 inches of mercury vacuum or higher is applied to the outlet of the venturi.

2.3.33. The installation of new C1 values in TDAP shall be simple and straightforward, but only available at the most restricted level of password protection.

2.3.34. Static pressure at the venturi inlet shall be measured using an absolute pressure transducer. This transducer shall have nominal range of 0-15 PSIA, with a 50% over-ranging capacity. This transducer shall utilize a temperature compensated and shunt calibration measurement technique. The static error shall be less than +0.2% of full scale or better.

2.3.35. The venturi inlet temperature probe shall be a platinum wire resistance temperature sensor (RTD), accurate to +0.2%, and shall meet the 100 ms response time (as measured in hot flowing oil) required by the CFR test regulations. The contractor shall certify this response and accuracy.

2.3.36. The CVS system shall provide for sample and ambient bag sampling for four independent test phases. The system shall also provide an easily accessible port for proportionally sampling and filling an “auxiliary” sample and ambient bag in parallel with the system at a varying and selectable rate. If the auxiliary bag is chosen as an option during test set up, a flow proportional sample shall be routed to this port during all sampled portions of the test. These ports shall be fitted with a self-sealing quick connect and may also be utilized for the external bag read function.

In addition to bag sampling, the CVS shall also provide continuous sampling of the diluted exhaust in the for "real time" gaseous analysis and shall provide for sampling for alcohol and aldehyde via a dedicated impinger/cartridge sampler.

2.3.37. The measurement system shall include a CFO kit with appropriately sized orifices to create a diluted concentration of propane equivalent to 50-100% FS at all flow conditions. The CFO kit shall provide for direct measurement of orifice temperature via RTD and digital readout, and measurement of pressure via transducer and digital readout, and 0-10V analog outputs for temperature and pressure for automated data

acquisition.

2.3.38. The delivered system shall include automated CVS verification routines per CFR along with automated routines, and associated hardware, to check concentrations at all sample point locations, including secondary dilution tunnels and bag mini-diluter, under steady state conditions, to demonstrate system integrity. Concentrations shall be compared to the concentration of a sample taken immediately adjacent to the main flow venturi. All observed concentrations shall not vary by more than 1% total (dilution corrected as appropriate.) These samples may be taken sequentially and may involve manual disconnection, movement and reconnection of a sample line. For calculation of all CVS verifications made by using a CFO kit utilizing pure propane, the density of pure propane at the CFO shall be assumed to be 52.83 grams/standard (1 atm., 20 deg C) cubic foot for injected mass calculations. The density of diluted propane withdrawn from a sample system shall be assumed to be 51.90 grams/cubic foot for bag mass recovery.

2.3.39. The sampling system shall include two separate dilution tunnels, one each for gasoline and diesel sample collection. Each tunnel will incorporate separate sample probes for particulate matter, heated gaseous samples, non-heated gaseous samples and at least one spare port.

2.3.40. Particulate and heated probe sample ports on dilution tunnels shall be fabricated from 2.5 inch “Tri-Clover” Butt Welding Ferrule, 316ss, Part #L14AM7, Solid End Cap, 316ss, P/N 16AMP, Type 1 Gasket, Silcone, P/N; 40MP-X, Clamp, P/N; 13MHHM, or equivalent materials.

2.3.41. The dilution tunnels shall be designed to facilitate rapid and complete mixing of sample and dilution air, and to minimize particulate losses to the tunnel walls, either from particles impacting the tunnel walls, or thermophoretic deposition. One potential design approach would be to utilize radial inflow dilution through a porous metallic membrane in the mixing zone portion of the primary tunnel. The purpose of the membrane wall tubing section is to allow a portion of the dilution air to be brought in through the perforated tunnel wall. By having an air velocity component originating from the tube wall, it is believed that this will overcome the natural driving force of particles to follow a strong temperature gradient (decreasing in this case) and attach to the tunnel wall. This strategy would facilitate rapid dilution of the sample and minimize particle contact with the tunnel wall as the sample is being diluted.

2.3.42. To minimize particle losses, the dilution tunnels shall also be designed to absolutely minimize the length of transport tube between vehicle exhaust and the tunnel. To accomplish this, the tunnels should allow a wide range of positioning in the x-y-z planes. The tunnel design shall carefully consider test cell layout and allow for optimum flexibility and ease of positioning. Tunnels may be oriented horizontally or vertically.

2.3.43. Particle losses shall also be addressed by minimizing the thermal mass of sample contacted surfaces through the mixing zone. For example, the transport tubes/adapters for connecting the dilution tunnels to the vehicle should be of double-wall construction with the inner wall made as thin as possible to minimize the thermal mass of the tube, while providing adequate mechanical strength.

2.3.44. Tunnels shall be designed to allow for assembly in a modular manner, to allow for future adaptations and advancements in the state of the art of particulate sampling.

2.3.45. The tunnel and particulate sampling system shall provide sufficient flexibility control and adjustability to maintain proper filter face temperature and appropriate filter mass loading for a wide range of vehicles and test conditions. The dilution tunnels shall meet the requirements of 40 CFR 86.110-94 and 40 CFR 86.1310-2007 with the following exceptions, modifications and clarifications:

There is no minimum mixing zone length requirement. Tunnels shall be made as short as possible to the extent that complete mixing is achieved, as defined in 40 CFR 86.1310-2007, under the full range of operating conditions specified in this Statement of Work. A formal report fully detailing the adequacy of mixing in the tunnel upstream of the sample zone, shall be provided to EPA in advance of final acceptance testing.

Tunnels shall be designed to accommodate both single and double dilution strategies. All requirements related to the construction and performance of secondary dilution tunnels, found in 40 CFR 86.1310-2007 shall be achieved. The measurement system shall also allow PM sampling directly from the primary tunnel at the user’s option. System designs, which require some straightforward mechanical reconfiguration to allow this, are acceptable. If PM is sampled directly from the main tunnel, the requirement for a minimum filter face temperature of 42 degrees-C found in 40 CFR 86.1310-2007 will not apply.

The system does not need to maintain temperatures below 52 degrees-C in the main tunnel under all conditions. Temperature in the main tunnel shall always remain below 191 degrees-C in the sample zone, or less as may be dictated by requirements of the CVS blower or other temperature-sensitive components. Maximum vehicle weights and US06 acceleration rates shall be utilized in determining heat inputs to the tunnel.

2.3.46. The particulate measurement system will utilize high efficiency membrane filters as described below. Back-up filters will not normally be used. Due to the high efficiency and relatively high pressure drop across these filters, a backup filter will not routinely be employed. A total of 300 filters shall be delivered with the system.

Nominal filter specification: Pall "Teflo" R2PJ047 - 47mm, or equivalent

2.3.47. The particulate sampling system shall provide for the automated simultaneous collection of up to three parallel filter samples, for up to four discreet sample phases without changing filter holders during a test. Filter holders shall be attached to the system by means of quick disconnects. In lieu of quick disconnects, other devices that consist of hinges or clamps are acceptable as long as they allow for easy, leak free installation and removal.

2.3.48. The sample flow rate for each individual filter shall be measured and reported so that individual gram per phase or gram per mile values may be calculated for each filter.

2.3.49. The filter face temperature for each filter location shall be measured, monitored and recorded during a test, unless other means are employed to ensure temperature uniformity across all filters. In any case, filter face temperature shall be measured and recorded in at least one location, or as otherwise required, to document test specific compliance with CFR requirements. If the temperature is not measured directly for each filter location, the contractor shall provide a detailed engineering report clearly demonstrating how the temperature requirement can be reliably met, and documented, by the system as designed.

2.3.50. The system shall include two sets of 12 filter holders, with cassettes and disconnects that comply with the requirements of 40 CFR 86.1310-2007. Filter holders and cassettes shall be designed in such as way as to reliably seal and prevent inadvertent damage to the filters during assemble or disassembly.

2.3.51. Filter holders shall be permanently marked, by etching or engraving both halves, as follows:

Phase 1-A
Phase 1-B
Phase 1-C
Phase 2-A
etc.
Phase 4-C

2.3.52. The system shall include a set of leak-tight plugged disconnects for sealing off any filter position not utilized during a test. Filter holders shall also include plugs, which may be easily inserted and removed from each end of the filter holder, to seal the holders during transport to and from the EPA filter weighing room.

2.3.53. The particulate collection system shall utilize particle classifiers, as referenced in 40 CFR 86.1310-2007. These shall be configured in such a way as to allow easy removal of collected debris.

2.3.54. The particulate measurement system shall include a particulate sampler with a sample pump(s) sufficiently sized to maintain proportionate sample flow for concurrent sample collection of at least three of the previously specified filters in parallel configuration.

2.3.55. The particulate sampler shall include three separate flow measurement devices for each of (up to) three filters sampled during a single test phase. The flow measurement system shall have a precision and accuracy of 0.5% under all conditions that may be experienced during testing.

2.3.56. The particulate sampler shall have an independent NIST traceable flow standard, isolated from sample flow, to verify sample flow measurement accuracy. The sampler shall provide for automated flow checking on command.

2.3.57. The particulate sampler shall provide for automated leak checking of the sampler system and filter holders.

2.3.58. The particulate sampler shall provide for operation and flow monitoring and totalizing in local mode.

2.3.59. The particulate sampler shall provide for other automated self-checks and diagnostic features as required by system design, to facilitate maintenance, troubleshooting, and repair.

2.3.60. The particulate sampling system shall include all equipment necessary for pretreatment of compressed air for secondary dilution and service requirements. EPA will provide compressed air at a minimum of 65 psi from an oil-free compressor. The equipment package delivered as part of this contract shall provide for compressed air, if pressure, or other compressed air quality requirements, exceed the nominal capabilities of the EPA compressed air system.

2.4 Bag Min-Diluter Sampling System (BMDSS)

2.4.1 The D329 measurement system shall include a BMD system comprised of a direct exhaust flow measurement device (commonly referred to as EFMS or DEVM), a constant dilution, proportional bag-filling system, all related dedicated control hardware and software, and a zero air purification device. In addition the system shall also be equipped with a dewpoint hygrometer to measure sample humidity. For purposes of this SOW, references to the BMD or BMD system shall be taken to mean the collection of all these devices.

2.4.2 The raw vehicle exhaust mass flow is to be determined continuously, and a continuous sample of raw exhaust shall be drawn and diluted immediately after the EFMS metering section at a constant, selectable volumetric ratio with dry, heated, ultra-pure zero air. This dilute mixture shall be drawn or pumped through a heated line to the bag proportioning mass flow controller.

2.4.3 The BMD shall incorporate flow control devices that provide a constant sample dilution ratio that can be set from 5:1 to 12:1. This dilution ratio shall remain at its pretest setpoint +/- 2% throughout the test and must be monitored, recorded and statistically summarized and reported for each sample phase.

2.4.4 The raw exhaust shall be diluted close to the vehicle source and then transported to the proportioning flow controller as a heated and diluted sample. This transfer shall occur as a continuous point by point flow stream with no large internal expansions that introduce non-linear concentration changes. One potential approach would be to use an in-situ ceramic filter that actually dilutes the raw exhaust at the source. This would enable the transfer of a dilute mixture at a high flowrate, which minimizes the potential for condensation and shortens the transport delay.

2.4.5 The dilute sample mixture shall be pumped to a flow controller which shall direct a proportional fraction of this dilute mixture into a sample bag. This sample flow must be proportional to the corresponding exhaust flow at the sample point, which means that the time delay between the point of flow measurement and sampling must be determined and utilized in the system design and operation. This is system dependent and must be determined by special tests. The results of this tests are to be reported in advance of system acceptance, as referenced in the Project Management section of this Statement of Work.

2.4.6 The bag fill sample to exhaust flow proportionality ratio shall remain constant during each test phase to within; ±5% on an instantaneous basis, ±1% phase average and 2% RMS. These criteria must be monitored, recorded, summarized statistically and reported for each sample phase.

2.4.7 The ambient operational conditions for the Mini-Diluter system shall be 60-100°F and 28-31 inches mercury, barometric pressure.

2.4.8 The BMD shall provide for measurement and control of the exhaust pressure drop at all flows to assure the tailpipe backpressure requirements are met. These requirements are identical to those of the CVS sampling system.

2.4.9 The BMD shall be designed to operate both in place of the CVS system, and in series with the CVS system. All BMD controls and signals shall be integrated with TDAP which shall acquire all data and report and calculate emission rates in a manner similar to that of the CVS method. The BMD shall be designed to work in an automated fashion, but shall also function in a “local” or operator driven, self-contained mode.

2.4.10 The static pressure of the gas entering any flow-metering device shall be measured using an absolute pressure transducer. This transducer shall have nominal range of 0-15 PSIA, with a 50% over-ranging capacity for atmospheric levels or ranged appropriately for higher pressures such as CFOs or MFCs. This transducer shall utilize a temperature compensated and shunt calibration measurement technique. The static error shall be less than +0.2% of full scale or better.

2.4.11 All flow meter inlet temperature probes shall utilize platinum wire resistance temperature sensors (RTDs), accurate to ±0.2%, and shall meet the 100 ms response time (as measured in hot flowing oil) required by the CFR test regulations for CVS systems. The normal temperature range will be ambient to as high as 700˚F on an intermittent basis.

Exhaust Flowrate Measurement System (EFMS)

2.4.12 The Exhaust Flowrate Measurement System (EFMS) shall be designed to be a vertically oriented unit to optimize the flow profile conditions at low velocities. The EFMS shall be mounted on a movable trolley system capable of supporting 2000 pounds and easily moved for different vehicle configurations. The building steel girders are 20' above the floor and a structural mezzanine is planned with a clear height of 12' above finished floor (AFF). This mezzanine structure and/or the building steel may be utilized to support the trolley rail system for supporting the movable EFMS. The contractor shall install all framework or supports that are required for the trolley implementation of the moveable EFMS.

The EFMS shall be designed with a compact, sturdy frame that is stable during movement. The EFMS shall be easily moveable by one person to accommodate connection to both front and rear wheel drive vehicles with exhaust outlets on left, right, or both sides. Push-pull handles shall be installed on each corner of the EFMS. The EFMS piping shall be arranged to occupy minimal footprint space. Heaters, water reservoirs, and pumps may be located remotely above the test cell space on the structural mezzanine.

2.4.13 The EFMS shall provide sufficient control, such as preheating, to prevent condensation in the raw exhaust stream. The exhaust flow measurement system shall be maintained at nominal temperature of 180˚F throughout the test.

2.4.14 The connection from the tailpipe to EFMS inlet shall be a 3" OD flexible stainless steel tube that has a 2.5" Marmon adapter attached to the vehicle end. This connector tube shall be as short as possible, but not be longer than 3 feet and shall be heated and insulated. The outlet of the EFMS shall be connected to a 4" OD mixing point connector to allow for subsequent CVS sampling. The length and size of this connector tube shall be selected to minimize any generation of resonant pulses that may adversely impact the EFMS measurement.

2.4.15 The EFMS shall incorporate and integrate an ultra sonic flow meter with fast response measurements and conversions, a dual heat exchanger to stabilize exhaust temperatures, pressure transducers, temperature sensors, controllers, and a computer interface for other equipment and data logging. The flow-meter shall operate using a differential inverse transit time principle. It shall incorporate two diametrically opposed ultrasonic sensors mounted at a 45 degree angle, with one sensor upstream of the other. Ultrasonic sound waves transmitted by the sensors shall alternate and be synchronized, allowing one to transmit while the other is receiving.

2.4.16 The EFMS shall include a nominal 2.5 inch diameter meter spool piece, enabling the measurement of exhaust flow rates from 3 ACFM at idle to a maximum of 325 ACFM. All flow data shall be available as ACFM and SCFM with associated temperatures, pressures, and date/time stamps. All data units of measure shall be selectable in English and SI terms.

2.4.17 The EFMS shall be used to measure the displaced volume of vehicle exhaust with changing temperature and pressure in the range of 3 to 325 SCFM. The EFMS shall integrate the transient vehicle exhaust flow (SCFM) over each test phase, and log all test related parameters, such as temperatures, pressures, ratios, and sample flows at 10 Hz, including all values that are required for the emissions calculation and measurement validation.

2.4.18 A NIST-traceable calibration of the meter over the flow range specified shall be completed to off-site system acceptance. The exhaust meter shall be calibrated with an accuracy of 1% of point, or better, over the useful dynamic range of the meter. The metering accuracy of the indicated total volumes of exhaust shall be accurate to ±0.5%. Software correction factors or curves, based upon and supplied with the prime calibration, shall also be utilized to improve the EFMS measurements over the full range of the meter.

2.4.19 The T90 response time of the EFMS to a step input change in exhaust flow (from a simulated source) shall be less than 0.3 seconds. This response time shall be correlated and synchronized to the bag fill mass flow controller on the Bag Mini-Diluter. A special propane injection shall be measured with a fast FID analyzer to verify the transient performance of the system.

2.4.20 The EFMS shall provide data output to the Bag Mini-Diluter in both analog and digital formats. The digital signal (serial RS485) shall be the primary source of data transfer between the exhaust flow system and the Mini-Diluter, and both shall be updated and sent to the Mini-Diluter at least once every 0.1 seconds. The delay time in processing, sending and receiving the digital signal shall be no more than 0.3 seconds (e.g. the Mini-Diluter must receive information on the exhaust flow within not more than a 0.3 second delay from the actual flow occurrence). This delay time shall be a constant value, which can be accommodated by using additional transport time delays that may be necessary to synchronize sampling actions. The basic goal is to achieve proportional mass sampling which is the integration of the variable product of concentration with associated flow.

2.4.21 The EFMS shall include software provisions to provide exhaust flow data to the Mini-Diluter in either a filtered or unfiltered (raw) form. The specific code and operating characteristics of the software filter shall be provided with the system. This filter shall not bias or alias the exhaust flow data. The parameters for the software filter shall be implemented as part of a set-up menu in order to facilitate revisions to the filter application.

Exhaust Dilution and Proportionate Sampling Section

2.4.22 The BMD cabinet, oven, and bag rack shall be packaged to minimize the equipment footprint and to provide easy mobility in the test site if movement is required. The packaging for the BMD design shall provide serviceability, allowing access to solenoids, filters, metering devices, and other components requiring maintenance. A calibration panel shall be supplied on the cabinet that includes the interface for all sensor (RTD, thermocouple, transducer, etc.) calibrations on the Mini-diluter.

2.4.23 Any cabinets or racks used to contain controls and displays shall utilize a standard 19" instrument rack mount. All function controls shall be clearly labeled and indicated when active. This display may be a combination of computer display screens for the programmable functions and physical hardware such as buttons, switches, lights, and meters for other appropriate functions. Connections to the flow control and measurement hardware shall be as modular as possible to allow for maintenance and reconfiguration. All connectors and appropriate lengths of cable shall be provided for the installation. Cable design and configuration shall anticipate the severity of use of a high volume testing operation.

2.4.24 The BMD shall use pumps with a Teflon diaphragm, a stainless steel head (with 16 micron finish), and rubber anti-vibration pads, such as KNF Neuberger 7261.1.2TPP, or equivalent. The pump(s) shall be sized to ensure adequate flow and pressure for the metering devices, such as critical flow in CFVs. A second pump shall be installed to evacuate the sample bags. These pumps shall be installed in a manner that facilitates ease of service or replacement.

2.4.25 All solenoid valves shall be two-way valves, normally-closed, rated for continuous duty. They shall be of a design that has minimized dead volume and surface exposure to the sample and a pressure drop that prevents condensation of moisture in the sample.

2.4.26 Teflon valve seats shall be used on solenoid valves to minimize system contaminant outgassing. Pressure regulators used to supply analytical, purge, and diluent gas shall use a stainless steel diaphragm. There shall be no Viton rubber used in the regulator or solenoid valves. All mounted components (solenoids, MFC, etc.) shall use a stainless steel base.

2.4.27 The plumbing for the Bag Mini-Diluter shall be electropolished 316 stainless steel or bright, annealed stainless steel tubing, chemically passivated with 10% nitric acid or equivalent. The sample lines shall be cleaned and baked, and demonstrated to be contaminant-free prior to assembly of the system. The sample lines from the BMD to the analytical bench shall also use the same material as used for the plumbing in the BMD. Short Teflon lines with a stainless steel overbraid may be used for the connections to the pumps for vibration isolation.

2.4.28 Sample lines shall be designed and configured so as to minimize the residual dead volume. A scheme that provides immediate dilution of the raw exhaust at the exit of the EFMS is the optimum real world simulation.

2.4.29 All components of the BMD that are exposed to either raw exhaust gas or diluted exhaust sample shall be heated adequately to prevent any condensation. This requirement does not apply to the BMD sample bags, which may remain at room temperature. Any filters and flow control meters shall be placed in an oven with a selectable temperature control range of 100-180 °F.

2.4.30 Filters used in the sample transfer shall have minimal dead volume and pressure drop, shall promote slug flow, and shall not react with the exhaust constituents. A small cylindrical sintered metal annular type filter may provide such characteristics. The exhaust sample filter shall be made of media that does not produce or absorb HC gases or in any other way interfere with chemical measurements within the scope of this contract. The filter shall be located appropriately for easy accessibility for replacement. The filter shall be protected so that its integrity is not effected when the sample pump is turned on or off. There shall be a readily observable indication of filter condition.

2.4.31 The BMD shall include any automated pressure regulation system and temperature controls that are required to maintain the dilution ratio of the diluted raw exhaust at its constant value ±2% over the entire test. For example, a DR of 5 shall not vary outside 4.9 to 5.1 during any point in the test

2.4.32 The BMD dilution ratio shall be nominally 5:1, with a total sample flow of 36 lpm, 6 lpm of exhaust and 30 lpm of zero air, or a dilution factor of 6. These flows shall be maintained and controlled by use of common flow metering devices such as CFOs, CFVs, or MFCs in a configuration that performs to the specifications. The temperatures and pressures related to each flow device shall be measured by transducers and logged with the test data.

2.4.33 The 5:1 dilution ratio shall be used for straight gasoline, Phase II (RFG II), and Phase III (RFG III) test fuels, and shall maintain the dew point in the Mini-diluter sample bags below 66°F. A second exhaust flow dilution ratio of approximately 10:1 shall also be provided to prevent water condensation (keeping the dew point below 66°F) when the vehicle being tested uses natural gas (CNG) fuel, which produces higher water vapor exhaust concentrations.

2.4.34 All flow metering devices shall be calibrated to an accuracy of ±1%, traceable to NIST, and shall have a minimum precision of ± 0.25%. A complete calibration report for these devices shall be delivered to EPA prior to system acceptance. At a minimum this report shall include flow coefficients, meter geometry, and flow sensitivity to a wide range of gases including air, nitrogen, mixtures of air/nitrogen and propane/CO_2 calibration gases, and a simulated stoichiometric exhaust gas mixture with common fuels.

2.4.35 Each metering device shall be uniquely identified and permanently labeled for easy cross-reference to system documentation. The labeling shall also include a flow directional arrow. All bag line plumbing shall also be labeled in keeping with this identification scheme.

2.4.36 The bag fill rate control function shall use a fast-response mass flow controller (MFC), with a full-scale range of 30 slpm. The T90 response to a step change in flow shall be 0.2 seconds or less. This mass flow controller shall be calibrated with air. Flow correction factors, particularly for the presence of water vapor and carbon dioxide, shall be supplied with the mass flow controller.

2.4.37 The proportional bag fill flow rate shall be scalable so the test phase bag will be filled to about 80% of its capacity at the end of the test phase. The bag fill rate shall be continuously proportional to exhaust flow and adjusted for transport delay. The bag fill sample to exhaust flow proportionality shall remain constant during each test phase to within ±5% on an instantaneous basis, ±1% phase average and 2% RMS. These criteria must be monitored, recorded, summarized statistically and reported for each sample phase.

2.4.38 The Bag-Mini-Diluter shall be supplied with five independently accessible sample storage bags fabricated from 4 mil Kynar or an equivalent alternative inert material mounted in a suitable bag rack. Four of these will be configured for dilute samples and one shall be used for a quality check on the zero air diluent.

2.4.39 The contractor shall provide a Bag Mini-Diluter system for Tier 2 testing that meets the performance requirements and provides the capabilities to measure the low levels of THC and NOx required by regulation. One objective in the overall design shall be to minimize any chemical interaction, such as contaminant outgassing, absorption, adsorption, exponential dilution mixing, condensation, etc., particularly at very low concentration levels, between the exposed materials and the sample. For Tier 2 sampling, HC outgassing from unconditioned Tedlar bags can contaminate the system plumbing and therefore is unacceptable.

2.4.40 Prior to system acceptance the contractor shall test the sample storage system for residual HC hangup and permeation by storing a humidified HC-free mixture of 3% CO2 in air for 24 hours at an ambient temperature of 80±4˚F. To be acceptable, the final THC concentration in the sample bag shall not change by more than 50 ppb (carbon) from the initial THC value. Also, the CO2 concentration must not change more than a maximum 600 PPM per hour, when measured at 1 hours, 2 hours and 24 hours. For purposes of this test, “humidified” shall be considered to be a dewpoint of 60±4˚F, and “HC-free” shall be considered to be less than 100 ppb (carbon).

2.4.41 The sample bags shall have crinkled surfaces to enhance evacuation with minimal internal plumbing. All bags shall be fitted with Kynar hubs and quick-disconnects and shall be mounted in a bag rack design that enables complete filling without interference and minimizes the transfer plumbing from the control valves. The bags and connections to the bags shall minimize dead volume and shall provide a sample capacity of approximately 100 liters (3 cuft).

Five additional sample bags shall be provided with the system as spares.

2.4.42 The bulkhead fittings on the BMD cabinet shall provide for bags, continuous dilute sample analysis, vent, dilution gas, and calibration gas. The bulkhead fittings shall be female Swagelock quick-disconnects.

2.4.43 All components in contact with exhaust sample, or diluent air, shall be made from materials that do not alter, contribute to, or interfere with the measurement of any chemical present in automotive exhaust.

<u>BMD Operation and Control</u>

2.4.44 The EFMS/BMD sampling system shall have two modes of control operation, a local (manual) mode and remote (automated) mode. Local control means that the function can be selected and controlled by the operator. The EFMS/BMD shall provide for local control at the EFMS/BMD interface, or “front panel”. Mode of operation shall be selectable on the front panel of the device and through the computer interface.

2.4.45 For local control, the BMD shall be supplied with a 19" flat screen, mouse, keyboard, microprocessor (or PC) and integrated software package. When placed in automatic mode, the TDAP shall initiate all BMD functions.

2.4.46 The display screen shall be capable of being remotely located in the control room, within 50 feet of other BMD hardware. For automated control, the BMD shall receive its control commands and shall send required data to the TDAP system.

2.4.47 The following functions and displays shall be available in local mode:

a Power On/Off

b System On/Off, including the tailpipe backpressure control function.

c Local and automatic (by TDAP) control modes selection

d Operation mode selection

e Dilution ratio verification via dilute gas analysis

f Evacuate/fill control for purging of sample storage bags between tests. The operator shall have the option of cycling an individual bag or all storage bags simultaneously.

g Independent selection of the individual dilute sample storage bags, or the diluent air bag for analysis. Selection may be made during filling or evacuating of other bags, but shall be prevented during the sample filling process of the bag itself.

h Display of both instantaneous flowrates and totalized sample volume from the MFC and the vehicle exhaust volume from the EFMS in standard cubic feet (760 mm Hg @ 68°F) shall be provided for each test phase. The system shall not allow data to be erased or reset by the operator until saved in the computer log file.

i Digital display of inlet pressure and inlet gas temperature for all metering device(s) used.

j Digital display of heated line and oven temperatures

k Indication of "bag empty" condition signifying completion of the individual bag evacuation cycle.

l On/Off status of all valves and pumps in conjunction with a BMD flow system diagram.

m Complete system leak test initiated by a single command, with a quantitative leak rate indication and test sequence lockout provision shall be activated in the event

of excessive (limits shall be definable) leakage until corrective action has been verified. Leak detection shall be by pressure decay.

n Warning messages

2.4.48 Mini-diluter operation mode selections shall include "Idle", where no gas is flowing, "Ready", where zero gas is routed through all metering devices, "Sample", where raw exhaust gas and dilution zero gas flows through the metering devices and a bag is selected for filling. The “Continuous Dilute Sample", is the same as "Sample", except that the gas is routed to the continuous dilute fitting instead of to the bags.

2.4.49 An option to run the BMD to obtain a continuous dilute sample shall also be provided. The zero, span, and ratio check functions shall also be available for the continuous dilute line (eg. By routing the zero, span, or ratio check gas to the continuous dilute fitting instead of to the bags). A heat traced and insulated transfer line, that is temperature controlled to 100°F, shall be supplied to transfer the BMD continuous dilute sample to the analyzer system. Emissions data shall be appropriately adjusted for sample transport and analysis and other time factors, as appropriate, and date and time stamped to facilitate synchronization.

2.4.50 The BMD software shall include alarms for:

a. Loss of flow control in either the sample or diluent meters

b. Failure of system leak check or bag leak check

c. Loss of serial communication link

d. Any other relevant BMD or EFMS hardware or software failure, which would adversely affect the quality of the test data.

These alarms shall be communicated to the main test site computer system (TDAP) and RMD so that they can be reported on the test report and flagged to test site personnel.

2.4.51 The BMD software shall provide for the calibration, verification and related documentation of all instrumentation on the Mini-Diluter, including pressure transducers, temperature sensors, humidity sensors, and mass flow controllers.

2.4.52 There shall be software control to turn each pump on/off separately. There shall also be a diagnostic I/O forcing screen, which may be used to turn on/off all digital input/outputs, and monitor all analog input/outputs.

Zero Air Purification Device

2.4.53 An ultra-pure zero air cleansing system shall be provided and installed by the contractor to supply diluent air to the BMD. This cleansing system shall further treat air supplied by the current NVFEL zero air generation system. The maximum concentrations supplied by the NVFEL house zero air system will not exceed

- 0.1 ppmC HC
- 0 .1 ppm CO
- 400 ppm CO2
- 0.1 ppm NO.

The ultra-pure zero air cleansing system shall consistently supply dry zero air with a background hydrocarbon concentration of less than 0.002 ppm C. Additionally, the background level for CO shall be less than 0.002 ppm, the background level for CO2 shall be less than 0.1 ppm, and the background level for NOx shall be less than 0.002 ppm (2 ppb).

2.4.54 The volumetric supply for this system shall be sufficient to provide ultra-pure zero air for at least three seperate BMD and SULEV analytical systems being operated simultaneously. As a back-up source of zero air (in-case the house zero air supply is down), bottled synthetic air shall be used. A dedicated six pack shall be stored in the adjacent cylinder room and plumbed to the room 329 test site via a dedicated line and regulator.

Dewpoint Temperature and Humidity Measurements

2.4.55 For some tests the specific humidity of the diluted exhaust mixture shall be measured. A dewpoint meter that utilize solid state capacitance type sensors shall be provided and connected by solenoid valves to the continuous dilute bypass path ahead of the proportional bag-filling MFC. The dewpoint meter inlet shall also be switchable to sample and measure the specific humidity of the dilution air and any bag samples. The transport line lengths shall be short to optimize the response time and shall be electropolished 316 stainless steel or bright, annealed stainless steel tubing, chemically passivated with 10% nitric acid or equivalent. The lines shall be cleaned and baked, and demonstrated to be contaminant-free prior to assembly of the system.

2.5 Low Level Gaseous Analytical Systems (Gasoline, Diesel, Gaseous, and Alcohol Fueled Vehicle Emissions)

2.5.1 The contractor shall provide two separate analytical systems and sample handling paths for the gasoline, diesel, CNG, LPG, and alcohol fueled vehicle tests sampled via either the CVS or BMD in either a continuous/integrated or bag-sample basis. While the analytics should be capable of accurately measuring exhaust from any of the fuels listed above, diesel exhaust or LPG exhaust shall not be measured using the same analytical bench used to measure exhaust from any other fuel. The analyzers shall be packaged to suit the layouts illustrated in the attached Figures, and information gathered from the pre-solicitation site visit.

2.5.2 All analytical systems shall use single range digital format analyzers that have high A/D resolution including five digits counts for zero and six digits at full scale span. The calibration and analyses processes shall use sampling and averaging algorithms to precisely determine gas concentrations that are generated by Tier 2 and SULEV vehicles. Tier 2 emission levels are primarily related to low concentrations of HC (total HC and methane as well as direct non-methane using the cutter catalyst method), NOx and extra low CO, as well as an optimized CO2 analysis capability

2.5.3 A magnetopneumatic style oxygen analyzer that can measure 0-25% oxygen concentrations, as well as a multi-gas photo-acoustic analyzer (ethanol, methanol, moisture, etc.) shall be integrated into the analysis system.

<u>Analyzer Performance Requirements</u>

2.5.4 The analyzers utilized in each analytical system shall comply with the following specifications.

Response - The analyzers shall respond to 95% of final reading within 3.0 seconds of the gas appearing at the analyzer inlet port. Down scale response must be such that the analyzer reads less than 2% of span reading (span = approximately 85% range) within 3.0

seconds of zero gas appearing at the analyzer inlet port. The time to achieve a true

zero from 2% of span should not be more than 30 seconds. This is required to prevent negative readings caused by high zero readings during zero/span adjustment.

Fast Response Analyzers- The fast response analyzers shall respond to 90% of final reading within 50 milliseconds of the gas appearing at the analyzer inlet port. Down scale response shall be such that the analyzer reads less than 5% of span reading (span = approximately 85% range) within 50 milliseconds of zero gas appearing at the analyzer inlet port.

2.5.5 Optimization - The optimization for all analyzers shall be an easily performed task (as automated as possible) and shall be fully described in the documentation or on-line procedures. This includes but is not limited to electrical and optical alignments, optimizing flows and pressures for FIDs and CLDs, as well as analog-to-digital converter and amplifier outputs.

2.5.6 Resolution and Repeatability - All analyzers shall be able to resolve a concentration that is ± 1% of the lowest quoted range of the analyzer. For example; if a dilute analyzer is quoted with a lowest range of 1ppm it shall have a resolution better than ± 0.01ppm and repeatability of better than 0.25% of the full scale value. The repeatability is to be tested over ten alternating zeros and spans each consisting of 1 minute zero and 1 minute of span gas at approximately 85% of full scale dynamic (FSD). All ranges must conform. Where single range analyzers are fitted the specification must be met on the minimum range.

2.5.7 Drift and Noise - Drift is to be less than ± 1% FSD over 2 hours in constant ambient conditions. Noise shall be less than ± 0.2% FSD of range or 1% of point, whichever is less. For example; for an analyzer with a low range of 1ppm the noise must be less than ± 0.02 ppm as measured by the %CV of 100 readings taken at 10Hz. Where single range analyzers are fitted the specification must be met on the minimum range as defined later in this specification.

2.5.8 Calibration - Analyzers shall be calibrated on each range identified as an active computer range using a suitable number of gas concentrations (cylinders and/or gas divider blends) to satisfy CFR requirements and to determine accuracy, resolution, and repeatability. For single range analyzers sufficient calibration points must be available to emulate the performance and response of a multi-range analyzer. Accuracy and repeatability limits should not be exceeded during the periods between calibrations.

2.5.9 The specifications for each analytical instrument shall be checked as part of the performance acceptance test process. The ranges specified are nominal values and some latitude and flexibility is permitted if the contractor substantiates the variation. Single dynamic range analyzers are acceptable, but auto ranging shall be provided for multiple range setups. If auto ranging is included in continuous measurement functions, it shall provide for "seamless" measurement without compromise as to accuracy, precision or data continuity.

2.5.10 Component Specifications

NO/NOx(LE) Oxides of Nitrogen Chemiluminescence Vacuum type detector for bags; atmospheric for modal SULEV testing to optimize the signal/noise ratio for low ppm.

Ranges	0-1-50, 100-1000 ppm (scalable dual range)
MinDetLevel	< 0.5% full scale (MDL = lowest conc that exceeds noise level spec)
Repeatability	< 0.25% full scale (STDEV of 10 zero/span readings)
Drift	< 1 % full scale in 2 hours (Zero and Span change from previous)
Response Time	3.0 seconds to 90 % full scale (LDV) at rated instrument sample flow
Noise Level	< 0.2% full scale (Noise = %CVar of 100 readings at 10Hz)
Non-Linearity	< 1% full scale (%NL = 100%*(.5*FS - Midscale)/Fullscale Conc)
Outputs	Digital display and transfer for computer storage (±x.xxxxxxE±nn), and analog output capability (0-5 or 0-10 VDC)
Temperature	Heated sample system (if required) shall be controllable at 235±15°F
Calibration	As per CFR 40, Part 86 using automated dividers and cylinders
Interference	As per CFR 40, Part 86 and results shall not be affected by the presence or absence of oxygenated materials such as methanol

<u>THC-FID</u> Total Hydrocarbon Flame Ionization Detector - (Heated)

Ranges	0-10-500, 100-5000 ppmC (scalable dual range) With option to go to 1 ppmC FS for SULEV/TIER 2 testing
MinDetLevel	< 0.5% full scale (MDL = lowest conc that exceeds noise level spec)
Repeatability	< 0.25% full scale (STDEV of 10 zero/span readings)
Drift	< 1 % full scale in 2 hours (Zero and Span change from previous)
Response Time	3.0 seconds to 90 % full scale (LDV) at rated instrument sample flow
Noise Level	< 0.2% full scale (Noise = %CVar of 100 readings at 10Hz)
Non-Linearity	< 1% full scale (%NL = 100%*(.5*FS - Midscale)/Fullscale Conc)
Outputs	Digital display and transfer for computer storage (±x.xxxxxxE±nn), and analog output capability (0-5 or 0-10 VDC)
Temperature	Heated sample system (if required) shall be controllable up to 235±15˚F
Calibration	As per CFR 40, Part 86 using automated dividers and cylinders
Optimization	As per CFR 40, Part 86 and CARB specifications

<u>Fast Response FID</u> Total Hydrocarbon Flame Ionization Detector - (Heated)

Ranges	0-10-500, 100-5000 ppmC (scalable dual range)
MinDetLevel	< 0.5% full scale (MDL = lowest conc that exceeds noise level spec)
Repeatability	< 0.25% full scale (STDEV of 10 zero/span readings)
Drift	< 1 % full scale in 2 hours (Zero and Span change from previous)
Response Time	50 milli seconds to 90 % full scale (LDV) from sample entry into the detector which may be remotely located to source
Noise Level	< 0.5% full scale (Noise = %CVar of 100 readings at 10Hz)
Non-Linearity	< 1% full scale (%NL = 100%*(.5*FS - Midscale)/Fullscale Conc)
Outputs	Digital display and transfer for computer storage (±x.xxxxxxE±nn), and analog output capability (0-5 or 0-10 VDC)
Temperature	Heated sample system (if required) shall be controllable up to 235 ±15˚F
Calibration	As per CFR 40, Part 86 using automated dividers and cylinders
Optimization	As per CFR 40, Part 86 and CARB specifications

<u>Extreme Low CO</u> NDIR, optical filter, capacitive type. Other technologies that are equivalent will be considered.

Ranges 0-10-500 ppm (scalable single range)
MinDetLevel < 0.5% full scale (MDL = lowest conc that exceeds noise level spec)
Repeatability < 0.25% full scale (STDEV of 10 random repeat readings of a gas)
Drift < 1 % full scale in 2 hours (Zero and Span change from previous)
Response Time 3.0 seconds to 90 % full scale (LDV) at rated instrument sample flow
Noise Level < 0.2% full scale (Noise = %CVar of 100 readings at 10Hz)
Non-Linearity < 5% full scale (%NL = 100%*(.5*FS - Midscale)/Fullscale Conc)
Outputs Digital display and transfer for computer storage (±x.xxxxxxE±nn), and analog output capability (0-5 or 0-10 VDC)
Calibration As per CFR 40, Part 86 using automated dividers and cylinders
Interference As per CFR 40, Part 86
The analyzers cross response to CO_2 and H_2O to be less than ± 1% FSD for ranges above 100 ppm. For ranges below 100 ppm cross response to be less than ± 0.1 ppm. Interference is to be tested by a mixture of 3% CO_2 in N_2 saturated by passage through a water bubbler at room temperature. Interference testing will be automated and performed without operator involvement, after the check starts.

<u>Low CO</u> NDIR, optical filter, capacitive type. Other technologies that are equivalent will be considered.

Ranges 0-50-2500ppm (scalable single range)
MinDetLevel < 0.5% full scale (MDL = lowest conc that exceeds noise level spec)
Repeatability < 0.25% full scale (STDEV of 10 zero/span readings)
Drift < 1 % full scale in 2 hours (Zero and Span change from previous)
Response Time 3.0 seconds to 90 % full scale (LDV) at rated instrument sample flow
Noise Level < 0.2% full scale (Noise = %CVar of 100 readings at 10Hz)
Non-Linearity < 5% full scale (%NL = 100%*(.5*FS - Midscale)/Fullscale Conc)
Outputs Digital display and transfer for computer storage (±x.xxxxxxE±nn), and analog output capability (0-5 or 0-10 VDC)
Calibration As per CFR 40, Part 86 using automated dividers and cylinders
Interference As per CFR 40, Part 86

<u>Low CO2</u>	NDIR, optical filter, capacitive type
Ranges	0-0.5-20 percent (scalable single range)
MinDetLevel	< 0.5% full scale (MDL = lowest conc that exceeds noise level spec)
Repeatability	< 0.25% full scale (STDEV of 10 zero/span readings)
Drift	< 1 % full scale in 4 hours (Zero and Span change from previous)
Response Time	1.5 seconds to 90 % full scale (LDV) at rated instrument sample flow
Noise Level	< 0.1% full scale (Noise = %CVar of 100 readings at 10Hz)
Non-Linearity	< 10% full scale (%NL = 100%*(.5*FS - Midscale)/Fullscale Conc)
Outputs	Digital display and transfer for computer storage (±x.xxxxxxE±nn), and analog output capability (0-5 or 0-10 VDC)
Calibration	As per CFR 40, Part 86 using automated dividers and cylinders
Interference	As per CFR 40, Part 86

<u>CH4-GC/HFID</u>	Methane bag analysis using columns and GC. Modal analysis by direct non-methane determination (Cutter using catalyst)
Ranges	0-1-50, 10-500 ppmC (scalable dual range)
MinDetLevel	< 0.5% full scale (MDL = lowest conc that exceeds noise level spec)
Repeatability	< 0.25% full scale (STDEV of 10 zero/span readings)
Drift	< 1 % full scale in 4 hours (Zero and Span change from previous)
Response Time	1.5 seconds to 90 % full scale (LDV) at rated instrument sample flow
	Sample column separation and analysis time of less than 1 minute
Noise Level	< 0.1% full scale (Noise = %CVar of 100 readings at 10Hz)
Non-Linearity	< 1% full scale (%NL = 100%*(.5*FS - Midscale)/Fullscale Conc)
Outputs	Digital display and transfer for computer storage (±x.xxxxxxE±nn), and analog output capability (0-5 or 0-10 VDC)
Calibration	As per CFR 40, Part 86 using automated dividers and cylinders
Other	FID response shall be optimized
	The methane cutter catalyst efficiency shall be tested using a mixture of ethane and air. The conversion of ethane shall be at least 98% when tested in accordance with the standard procedure specified by the manufacturer.

OXYGEN in Air	Magnetopneumatic measurement principles. Response shall be linear over its dynamic range.
Ranges	0-1-25 percent (scalable single range)
Noise Level	< 0.2% full scale (Noise = %CVar of 100 readings at 10Hz)
Non-Linearity	< 5% full scale (%NL = 100%*(.5*FS - Midscale)/Fullscale Conc)
Outputs	Digital display and transfer for computer storage (±x.xxxxxxE±nn), and analog output capability (0-5 or 0-10 VDC)
Calibration	As per CFR 40, Part 86 using automated dividers and cylinders
Interference	As per CFR 40, Part 86

2.5.11 Permanent labels shall be attached to the analyzer console, in English, to identify each analyzer in the console and the dynamic extents of each analyzer's amplifications.

Sample Analytical System for Gasoline and Alcohols (BMD and CVS)

2.5.12 The analytical system shall contain instruments meeting the specifications listed above. The following additional items shall also be incorporated:

NOx converter efficiency tester - fully automated per the CFR.

Sample handling system for bag or continuous dilute samples. This system shall include an automated heated purge of the sample transfer path to remove residual HC contamination. Such as system is described in SAE paper 2002-01-0046.

Controls providing each analyzer with the ability to read:

- Response optimization (flow and pressure adjustments)
- Real-time dilute exhaust gases - both BMD dilute and CVS
- Zero gases (air and nitrogen from ultra pure gas generators)
- span gases (directly connected and dynamically blended on-site for midspan checks)
- Bag samples (both direct CVS samples and a hand carried correlation bags)
- Calibration gases (directly from cylinders or from automated dividers)
- CO2 interference on the low CO analyzer

- Methane response test per the specifications of the CARB (California Air Resources Board) with the options to update response factor or to input other factors for methanol, ethanol, or up to four auxiliary HC compounds.

2.5.13 The heated FID and heated NOx shall be configured for the direct, continuous measurement from exhaust transport tubing in addition to analyzing the collected bag samples. A heated sample line that is less than 15 feet long shall be furnished for this connection. The temperature of heated components shall be uniform, not varying by more than 20% of the nominal setpoint range at any point. The units shall also contain a heated pump and filter. All lines connecting the heated analyzers to the system manifold, sample bags or other areas shall be heated in accordance with the CFR requirements.

2.5.14 Automated calibration and verification of the calibration curves, and quality control diagnostics to enable the assessment of long term trends or changes in analyzer performance characteristics shall be provided. A gas divider or blending device capable of generating accurate calibration gases automatically and meeting the minimum requirements of the CFR Part 86 and the NVFEL in-house test procedure criteria for all analyzers - bag and modal. A flow calibration certificate, to a traceable National Standard, should be provided. The contractor shall provide a gas divider system that has the capability to generate 25 or more user definable points with the minimal cutpoint at 0.2% FS and with an accuracy of ±1% of point down to 10% of full scale. Complete calibration sequences shall be possible via manual control or automatic computer control in an unattended mode.

2.5.15 This analytical system shall contain instruments meeting the specifications listed for the BMD and CVS. In addition, this system shall provide for continuous modal heated HC and NOx measurements, per CFR requirements, which shall be combined, with flowrate data to provide mass emission rate values and integrated totals for the test phase. Other gases shall be measured with a heat traced transfer path that prevents any sample condensation.

2.5.16 Modal sample lines shall be equipped with temperature regulation, monitoring and alarm capability. This system shall also integrate hardware and automated functions for leak checking, backflush purge, zero/span via an overflow configuration, and the capability to measure sample hangup in the line and to purge it.

2.5.17 Analytical Response rates and transport delays shall be measured, documented, and compensated for in the entire system and modal measurement process. Specific automated functions shall be provided for checking and updating response times.

Gas Cylinder Plumbing and Control

2.5.18 Plumbing for the transfer of zero and span gases, as well as the dilute exhaust samples, shall be of 316 passivated and electropolished stainless steel (Ra<10) tubing construction only. Short lengths of steel braided Teflon tubing may be used on pump inlets and outlets for vibration isolation. All solenoid valves will have stainless steel bases and plungers constructed of a durable material which does not out-gas or otherwise change the composition of the gas flowing past them.

2.5.19 EPA shall provide up to 40 span gases, with cylinder regulators, from a central location adjacent to the test site. The contractor shall provide and install the span gas valves and permanently-mounted stainless steel lines to connect these with the analytical systems. The ends of each line end shall be labeled with the line number, gas type, concentration, and units and shall have a shutoff valve. Valve racks shall be constructed adjacent to each analytical system. Of the 40 lines 8 low concentration span and zero gas connections shall be dedicated for the EFMS/BMD and TIER 2 test capability. The contractor shall provide the parts and all install the connecting lines and fittings to BMD system.

Stainless steel lines shall use 1/4" fittings. Span gas pressures shall be set at a nominal 15 psig and the cylinder and shall be controlled by dedicated low concentration regulators. Internal analysis system regulators shall provide for the final pressure regulation for consistent flow control in the zero, span, and sampling modes to minimize any effects from pressure differences. All span gases including zero, span, ozone generator source gas, and FID fuel shall have sintered metal filters fitted to their respective bench inlets.

2.5.20 Each analyzer shall have one span gas and one mid-span gas inlet per computer active analyzer curve. Span gases can be shared between analytics and ranges, where concentrations permit.

Span concentrations shall be between 85% and 95% of the nominal upper range concentration. Mid-span gases shall be between 15% and 50% of the nominal upper range concentration. The bench should be capable of providing a dedicated mid-span for each curve established on an analyzer or using a lower span gas as the mid-span for a curve.

2.5.21 For gases, such as low (less than 25 ppm) HC, CO, and NOx, that may be unstable in high pressure cylinders, the system shall provide a computer automated, on-line, span and mid-span gas generation capability. This capabilility shall utilize higher concentration span gases, and the zero gases, with high accuracy flow proportioning devices, such as a CFO, to provide suitable span and mid-span concentrations.

Dynamic blending accuracy shall be +/- 0.5%, or better. Curves verification shall be achieved if the analyzer measures to within 2% of the blended value read at midspan.

Gas Sample Transfer for Analysis

2.5.22 All pump components in contact with the gas must be of materials which are unaffected by prolonged exposure to exhaust and span gas and must be mounted so that they produce no unwanted effects via vibration transmission. The pump materials should also be constructed of materials which do not contribute to the sample concentration through out-gassing. All internal pipework to be electropolished passivated stainless steel. PTFE or other suitable material not effecting gas concentrations can be used but should be minimized. Additionally, all service inputs must be clearly labeled.

2.5.23 Any fittings used must be compatible with the pipework installation, be good quality and installed to good engineering practices. All pipework systems should be pressure tested and proven to have no leaks. As installed there must be no contamination that would influence measurements on any available ranges of the analyzers. Low range analyzers require purge of the analytical equipment and back flush of the sample lines. This should be performed with a suitably clean supply of zero Nitrogen

2.5.24 Filters shall be provided to remove particles bigger than 0.3 micron in the sample before entering any analyzer. These filters shall have an efficiency of greater than 99% and be made from a non-reactive material. Filters shall also not contain any large changes in volume cross-section which cause exponential decay/shift of a transient modal concentration profile.

2.6 Alcohol and Aldehyde Sampling Systems

2.6.1 The D329 system shall support the sampling of alcohol, aldehyde and other similar constituents from automotive exhaust for analysis via both impinger/cartridge collection for off-site analysis and direct on-site analysis via a photoacoustic spectroscopy (PAS) infra-red detection system.

2.6.2 The contractor shall provide an impinger/cartridge system for collecting dilute exhaust samples during each test phase, to quantify the amount of alcohol and aldehyde in the exhaust. This system shall utilize DNPH cartridges and water impingers.

2.6.3 The impinger/cartridge shall fully integrate sample flow measurement and control that provides for proportional sampling of the dilute exhaust bulk stream. These samples shall also be obtainable from the both the CVS system or the excess bypass flow stream from the BMD by incorporating a second MFC to maintain proportionality.

Sampler flow controller functions, measurement accuracy and proportionality shall be equivalent to the relevant functions specified for the particulate matter collection system in this Statement of Work.

2.7 Direct Alcohol and Formaldehyde Analyzer

2.7.1 The contractor shall also provide for the direct analysis of ethanol, methanol and formaldehyde emissions by instrumentation, fully integrated with their analytical systems and other components of the overall measurement and control system. Based on the prevailing technology in use, and limited, conditional EPA method acceptance, this instrument shall incorporate the INNOVA 3433 photoacoustic spectroscopy (PAS) infra-red detection method.

2.7.2 The INNOVA 3433 model, which is similar to the model 1314 but with synchronous mode capability and many other desirable features, shall be used to analyze water vapor plus ammonia, formaldehyde, ethanol, methanol and carbon dioxide based on the installation of the proper optical filters. The analyzer shall be factory calibrated using NIST traceable gas SRM gas standards and all calibration data shall be provided with the instrument. These calibrations shall quantify interferences and correction factors for the gases of interest. Sample integration times and cycle frequency shall be selectable on a per gas basis. The instrument shall meet all of the specifications detailed in the INNOVA Product Data brochure available on their website - http:/www.innova.dk/Products/1314/1314.htm. One exception is that the sample handling units should NOT contain the sintered metal filter on the sample inlet. A conventional filter shall be installed and shall be easily changeable.

3.0 Calibration and Other Support Equipment

3.0.1 The contractor shall supply, install and integrate an electronic barometer with an accuracy of 0.03 inches mercury, or better, as part of the measurement systems for D329 and D005.

3.0.2 The contractor shall supply, install and integrate an electronic hygrometer, Visala HMP 233 with remote display, as part of the measurement system for D329.

3.0.3 The Tier 2 test sites will be used to measure very low emissions, so the ability to assess this capability with respect to precision and accuracy is extremely important.

3.04 Except as noted elsewhere, the contractor shall provide a supply of consumable items sufficient for approximately 6 months of operation.

4.0 Documentation Requirements

4.0.1 The contractor shall provide complete documentation for each system in this contract, including wire lists, color coding, electrical schematics, piping/tubing diagrams, operating and repair manuals and computer system documentation.

4.0.2 For each system a minimum of four sets of each document shall be provided and when available, the contractor shall also provide the documentation in computer readable user modifiable form. Microsoft Word, WordPerfect, AutoCADD, VectorWorks and Microsoft Excel are acceptable file formats as well as any that are compatible with standard translator/conversion tools provided by those applications.

4.0.3 The contractor shall provide a recommended calibration, verification and preventative maintenance plan, which will detail calibration, verification and preventative maintenance procedures, schedules, and recommended spare parts inventory.

4.0.4 The contractor shall provide a listing of all proprietary system warning and alarm messages, with full explanation as to their exact meaning, impact and action required.

4.0.5 The contractor shall provide a complete “Lock-Out, Tag-out” instruction for equipment requiring energy-isolating devices in accordance with the OSHA rule on the Control of Hazardous Energy (Lockout/Tagout) of Title 29 of the Code of Federal Regulations (29 CFR) Part 1910.147.

4.0.6 The contractor shall provide complete documentation of the quality control features of the delivered systems, and instructions as to their maintenance and utilization. This documentation shall be sufficient to provide system documentation and instruction to satisfy the relevant requirements of ISO DIS 17025 - General Requirements for the Competence of Testing and Calibration Laboratories

4.0.7 The contractor shall supply a list of consumable items with recommended supply sources, as well as a recommended parts list for routine maintenance operations.

5.0 Acceptance Testing Requirements

5.0.1 The contractor shall develop a comprehensive final acceptance plan, approved by EPA, which will verify that all requirements contained in this Statement of Work, and referenced documents, have been achieved in the delivered system(s). This verification will take place at the contractor's point of final assembly prior to delivery of the system to EPA.

The contractor shall deliver the acceptance plan, satisfactory to the EPA Project Officer at least 30 days prior to the start of the acceptance process. Prior to commencement of acceptance testing, the EPA Project Officer must approve the acceptance plan, in writing. Once approved, the contractor shall provide the EPA Project Officer with a detailed schedule of acceptance activities at least 7 days in advance. At least 2 days in advance, the project officer will indicate which activities EPA personnel will observe.

5.0.2 The acceptance shall be based on demonstrated performance, including actual vehicle testing. The contractor will repeat this verification process again after installation at NVFEL to the extent necessary, to verify full compliance with the requirements in the final installation. The plan shall consider all aspects of measurement system variability, so that all test results demonstrate compliance with an estimable and high level of statistical confidence.

5.0.3 All acceptance testing shall be the responsibility of the contractor. The contractor, at the contractor's expense shall rectify all non-compliant conditions. If repairs or changes are made, the contractor shall repeat acceptance testing to demonstrate the acceptable quality of the final product, to the extent necessitated by the scope of the repair or change. The contractor shall prepare a report for each phase of acceptance testing that describes all the various tests and reviews conducted as part of the acceptance activity, the outcomes of those tests and a description of follow up actions, as required.

5.0.4 EPA personnel shall observe the acceptance process. The EPA Project Officer may waive the opportunity to observe certain aspects of the acceptance process.

5.0.5 The acceptance plan shall be cross-referenced, section by section in a straightforward manner, to the requirements of this Statement of Work. The plan shall be designed in such a manner as to also form the basis of a final acceptance report. The acceptance plan shall also address all other requirements deemed significant and appropriate by the contractor, based on the specific design and configuration of their system and significant proprietary features.

5.0.6 Upon completion of the off-site testing, the contractor shall deliver a preliminary acceptance report to EPA. This report shall provide documented evidence of compliance to the requirements of this Statement of Work and the Acceptance Plan, with content and format suitable for successful audit to ISO DIS 17025 standards.

5.0.7 Vehicle testing portions of the acceptance activity shall be performed at a sufficient range of conditions and over a sufficient range of test types to fully and statistically demonstrate compliance with the requirements of this Statement of Work and applicable regulatory requirements.

5.0.8 Acceptance activities shall include an evaluation of the potential for aliasing or other inadvertent system effects on precision and accuracy.

5.0.9 In addition to the requirements stated above, acceptance testing shall demonstrate correlation of the Bag-Mini Diluter and CVS systems, tested in a series configuration within the following limits:

± 0.5% - CO_2 mass emission
± 2% - NO_x, CO and HC mass emission at nominal 0.08, 0.20 and 0.08 gpm levels

This testing shall include a condition of long vehicle crank time, during which vehicle ignition system shall be artificially inhibited between 7 and 10 seconds. This shall be demonstrated with a vehicle that has a small engine displacement (2.0L or less) and no provision for temporary storage of hydrocarbon.

The contractor shall be responsible for providing a suitable vehicle for acceptance testing at their site. EPA will provide a vehicle for final acceptance testing at NVFEL.

5.0.10 The demonstration of dynamometer interface requirements shall be exempt from off-site acceptance testing, but shall be included in acceptance testing at NVFEL.

6.0 Warranty

6.0.1 Contractors shall warranty the performance and functionality of their systems for a minimum of one year after formal EPA system acceptance and approval.

6.0.2 This warranty shall provide for cost-free repair or replacement of covered hardware and software. This warranty shall not reduce any requirement in this Statement of Work.

6.0.3 Contractors shall also offer options for 1-year and 2-year extensions to the base warranty period. These options shall be exercisable for up to 90 days after final system acceptance by EPA.

7.0 Training

After the systems have been commissioned and preliminary acceptance tests have been completed, the contractor shall provide at least 16 hours of basic training for up to 8 people and 24 hours of advanced training and systems administration for up to 6 people. The content of advanced training shall be selectable by EPA. This training shall be conducted on the installed system at NVFEL or at a mutually acceptable location. The training shall be completed within 30 days of final system acceptance by EPA.

8.0 D005 Option

The contractor shall offer an option to provide an additional, complete measurement system as referenced in Section 1.3.2 of this SOW. A schematic of the physical layout of this cell may be found in Figure 3. This system will incorporate several of the same component features of the D329, but the overall scope of this system is reduced as follows:

8.0.1 TDAP - The provided system will parallel the system referenced in the D329 except that the functionality will be reduced to those required by the more limited scope of testing to be accomplished at the D005 site.

8.0.2 All requirements specified for the D329 system apply except those that relate directly to the reduced scope of the sampling and anaytical components outlined as follows. This dynamometer site is not intended to support particulate sampling, diesel vehicle testing, direct measurement of any alcohol or aldehyde components or sampling via impingers and cartridges. Therefore, the dual sampling system requirement for D329 does not apply.

8.0.3 The general operation and configuration of this system shall be identical to the D329 system for all included features, so that operations and support personnel can operate both sites with optimum efficiency.

8.0.4 There is no requirement for HEPA filtering of dilution air. The CVS dilution air inlet shall be connected to the existing EPA dilution air pretreatment system. This system provides filtered, dried and warmed dilution air. This system is typically only used in order to minimize sample dilution for low emission vehicles tested with a conventional CVS/Bag Sampling system. The contractor-provided CVS system shall perform in an equivalent manner whether or not the dilution air pretreatment system is operational.

8.0.5 The requirement of 2.3.29 is replaced as follows:

For metering of diluted exhaust gas the CVS shall utilize three selectable CFVs - 250, 350 and 500 scfm (68 °F and 760 mm Hg) flow rates. All possible combinations of flows, from 250 to 1100 scfm, shall be available through simple set-up procedures within TDAP. The flow rate selection valves shall be leak-tight and shall enable automated switching of flow rates in less than 2 seconds.

8.0.6 The contractor provided system shall include an in-floor, insulated u-shaped dilution tunnel similar to that found in Figure 4. The contractor shall be responsible for all site preparation work required for this installation.

8.0.7 The D005 system shall include a Bag Mini Diluter system as specified in Section 2.4. The mounting system for the EFMS shall be adjusted for the differing ceiling conditions and reduced clearances of D005. The contractor shall be responsible for any physical adaptation of the actual test cell necessary for this installation, including the possible relocation of an existing return air duct.

8.0.8 The D005 system shall include an analytical system as specified in Section 2.5 of this Statement of Work. The D005 system shall require those components specified for the analysis of exhaust from gasoline, phase-2 fuel and CNG vehicles only.

8.0.9 The D005 system shall not include any capability for the direct measurement of alcohol or aldehyde compounds.

8.0.10 The D005 system shall include all general requirements and the requirements of Sections 4, 5, 6 and 7 of this statement of work, as well as the D005-specific requirement of Section 3.

8.0.11 Prior to delivery, EPA may, at their option, redirect installation of this system to D001, or other test site, which is substantially similar in all material respects to D005.

9.0 D002 Option

9.0.1 The contractor shall offer an option to provide a Bag Mini Diluter system as referenced in Section 1.3.2 of this SOW.

9.0.2 D002 houses an existing 48 inch roll electric dynamometer as well as a low level emissions measurement system described in Appendix D. This measurement system is approximately 2 years old and contains many of the features required for the D005 system described above, with the exception of the bag mini-diluter sampling system. The basic equipment utilized at this test site is as follows:

Dynamometer	Horiba LDV-125 48-inch roll
Analyzer:	Horiba MEXA 7200 DLE
CVS:	Horiba CVS-7200S with modified bag leak check provisions, SVF dilution air flow measurement and tailpipe pressure control
Test Control and Data Acquisition:	Horiba CDTCS-5000, Hewlett-Packard Series 9000 Computer system, UNIX

9.0.3 This contract option shall provide for the complete integration of a bag mini-diluter sampling system, as provided in the above referenced systems, with the existing D002 measurement system. The implemented system shall provide all necessary interaction and supplementation of the existing system required to provide for full operational, reporting and quality control capability.

9.0.4 The mounting system for the EFMS shall be adjusted for the differing ceiling conditions and reduced clearances of D002 which are very similar to the conditions found on D005. The contractor shall be responsible for any physical adaptation of the actual test cell necessary for this installation, including the possible relocation of an existing return air duct.

9.0.5 The D002 system shall include all general requirements and the requirements of Sections 3, 4, 5, 6 and 7 of this statement of work.

Figures

Figure 1. Measurement System Architecture

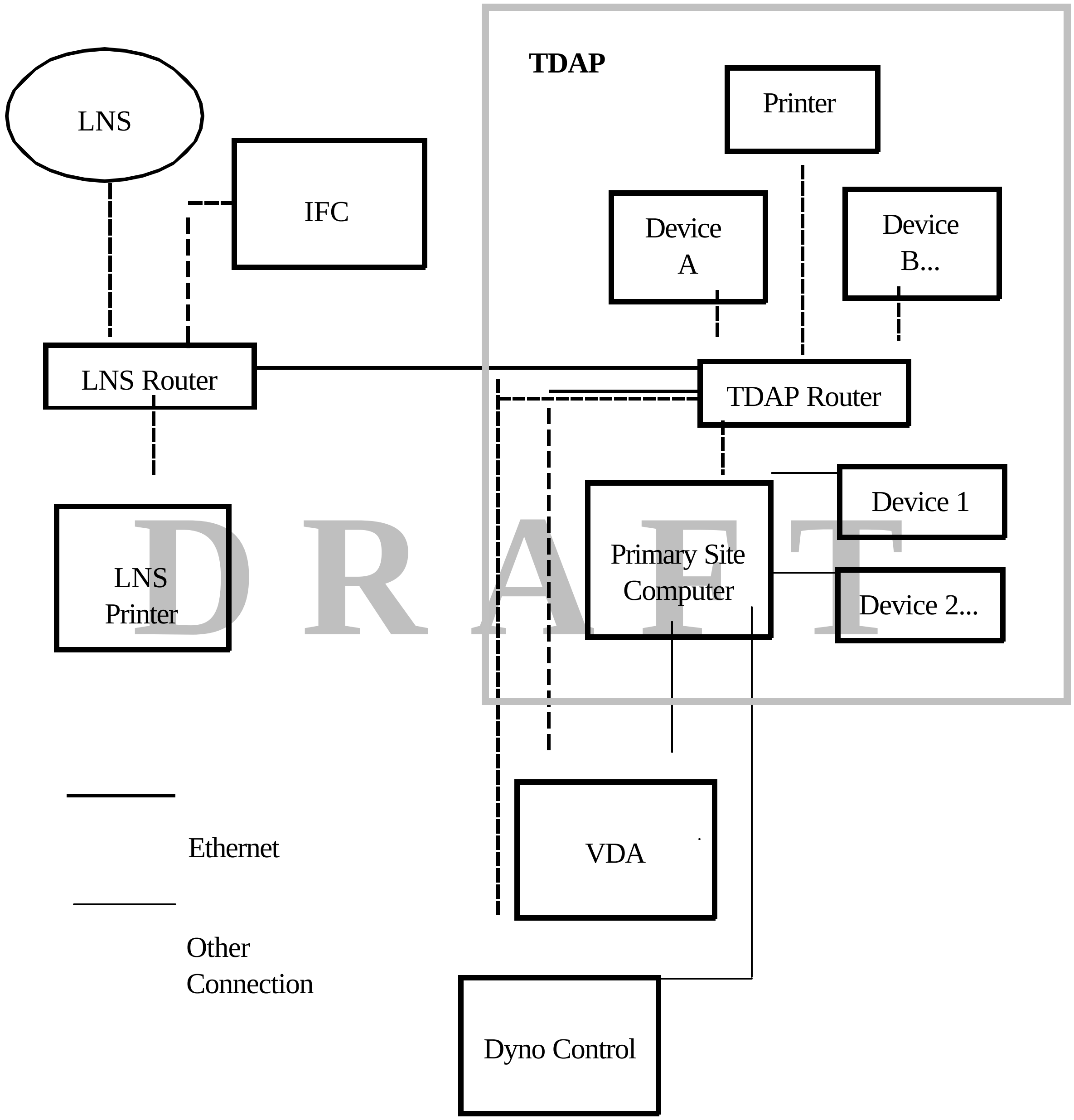


Figure 2. D329 Layout

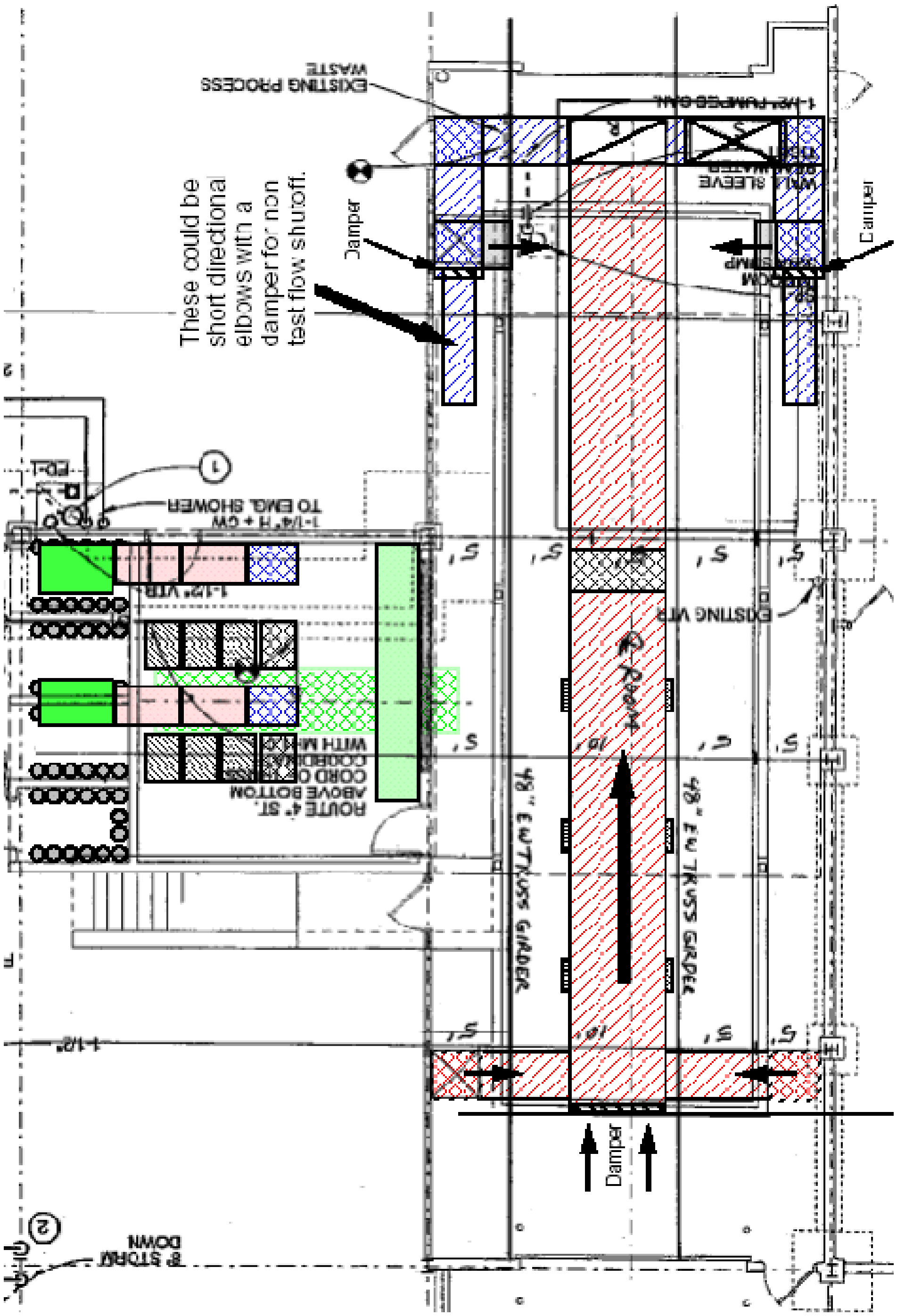


Figure 3. D005 Layout

Available control room area will be completely cleared prior to installation

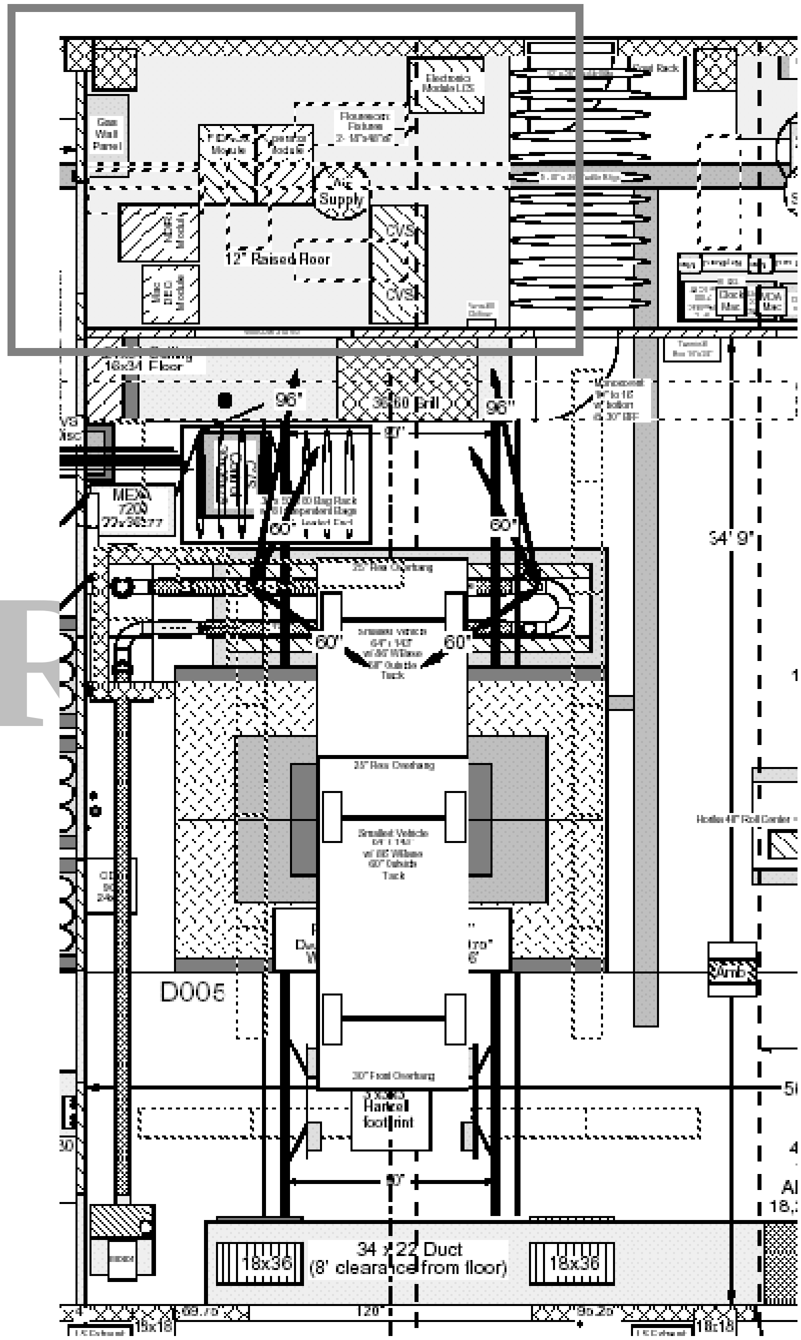


Figure 4. D002 Layout

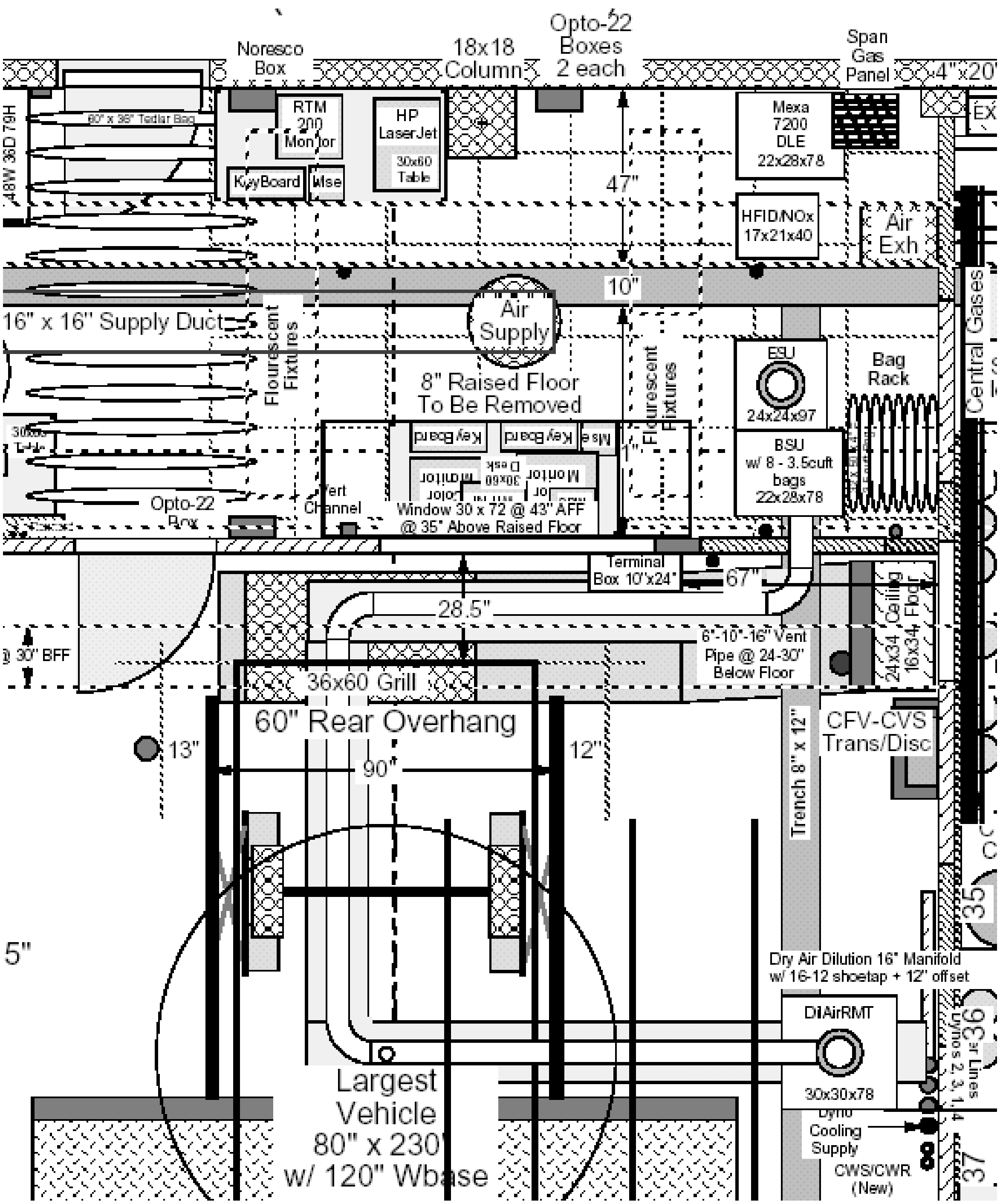
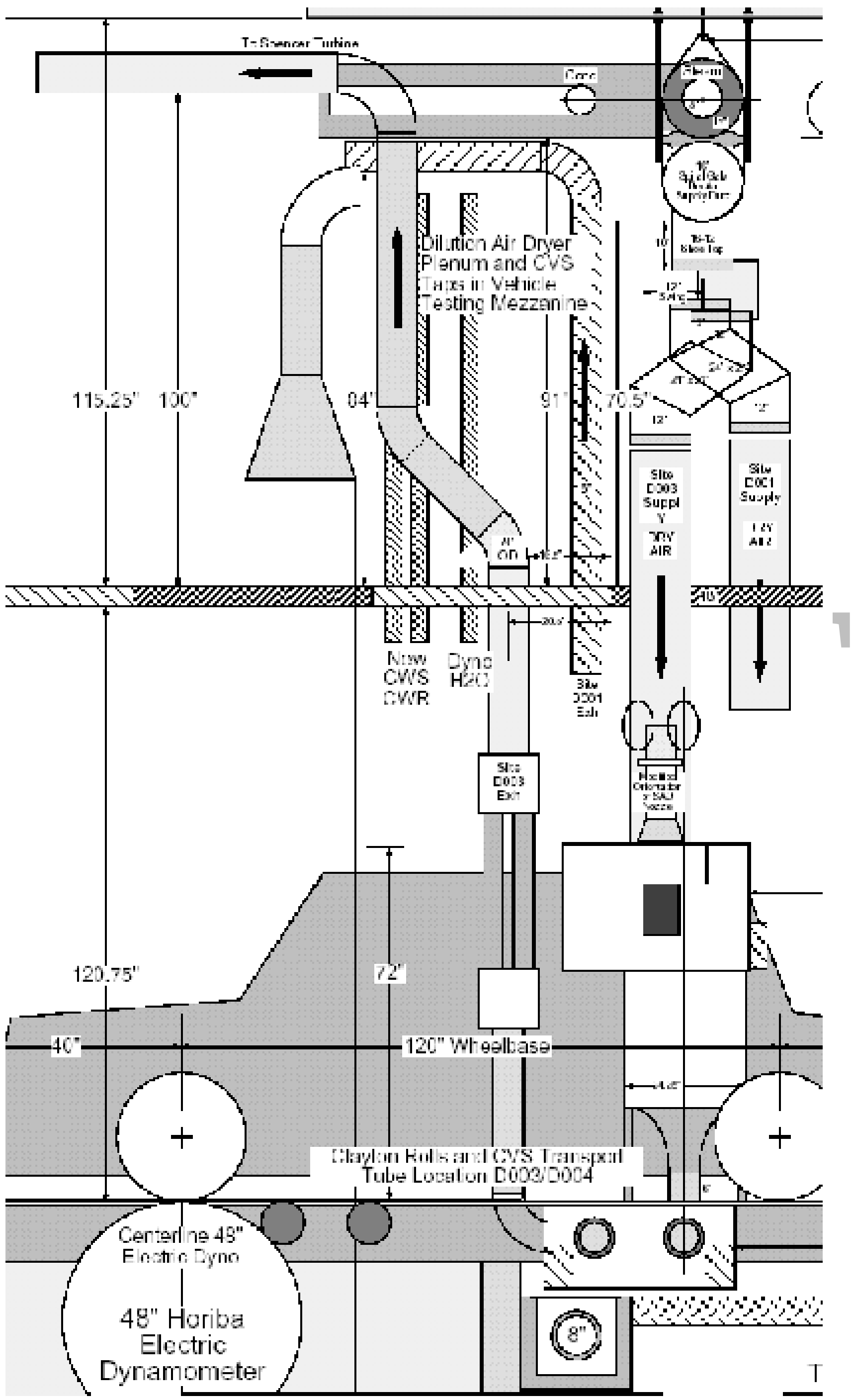


Figure 4. D002 Layout (Cont.)



Appendices

Appendix A

Abbreviations and Terms

AISC	-	American Institute of Steel Construction
ASHRA	-	American Society of Heating, Refrigeration, and Air Conditioning Engineers
ASME	-	American Society of Mechanical Engineers
BMD	-	Bag Mini-Diluter
BOCA	-	Building Officials' Code of America
CAA	-	Clean Air Act Amendments
CARB	-	California Air Resources Board
CFH	-	Cubic Feet per Hour
CFM	-	Cubic Feet per Minute
CFO	-	Critical Flow Orifice
CFR	-	Code of Federal Regulations
CFV	-	Critical Flow Venturi
CL	-	Chemiluminescence Analyzer (NOx)
CNG	-	Compressed Natural Gas
CVS	-	Constant Volume Sampler
DF	-	Dilution Factor, expressed as (parts diluent + parts sample)/parts sample
DR	-	Dilution Ratio, expressed as parts diluent : parts sample
EFMS	-	Exhaust Flow Measurement System
EPA	-	Environmental Protection Agency
FID	-	Flame Ionization Detector
FM	-	Factory Mutual
FTIR	-	Fourier Transform Infra Red
FTP	-	Federal Test Procedure
HEPA	-	High Efficiency Particulate Absorption
HFET	-	Highway Fuel Economy Test
HZ	-	Hertz (per second)
IFC	-	InterFace Computer
ISO	-	International Standards Organization
LA4	-	Los Angeles Driving Cycle #4
LPM	-	Liters Per Minute
LNS	-	Laboratory Network System
MFC	-	Mass Flow Controller
MSDS	-	Material Safety Data Sheets
NDIR	-	Non Dispersive Infra Red
NEC	-	National Electrical Codes
NEMA	-	National Electrical Manufacturers Association
NFPA	-	National Fire Prevention Association

NIST	-	National Institute of Standards and Technology
NMOG	-	Non-methane Organic Gas
NVFEL	-	National Vehicle and Fuels Emissions Laboratory
OBD	-	On-Board Diagnostics
OSHA	-	Occupational Safety and Health Administration
PM	-	Particulate Matter
P/N	-	Part Number
POC	-	Point of Contact
PSIA	-	Pounds per Square Inch Absolute
PSIG	-	Pounds per Square Inch Gauge
RFP	-	Request for Proposal
RMD	-	Remote Messaging Display
RPM	-	Revolutions Per Minute
RTD	-	Resistance Temperature Detector
SCFH	-	Standard Cubic Feet per Hour
SCFM	-	Standard Cubic Feet per Minute
SOW	-	Statement of Work
SJI	-	Steel Joist Institute
SLPM	-	Standard Liters Per Minute
T90	-	Time for an instrument to reach 90% of it's eventual reading for a given, constant condition
TDAP	-	Test-control, Data Acquisition and Processing system
UBC	-	Uniform Building Codes
UDDS	-	Urban Dynamometer Driving Schedule
ULEV	-	Ultra-Low Emitting Vehicle
VAC	-	Voltage w/ Alternating Current
VDC	-	Voltage w/ Direct Current
VDA	-	Video Driver's Aid
WC	-	Water Column

Appendix B

Video Driver's Aide (VDA)

The Driver's Aid computer will be provided by EPA and will meet the specifications of the Interface Computer as described in Appendix C.

The Driver's Aid will allow the driver to select scheduled tests. The Driver's Aid will accept pendant commands from the driver including, start vehicle or crank or key-start, vehicle start or start trace scrolling, pause trace, resume trace scrolling, abort test, engine stop or engine shutdown.

The Driver's Aid shall provide with Driver with the vehicle speed versus time trace display for both target vehicle speed and actual vehicle speed.

1. <u>General Characteristics</u>

1.1 Matching keyboard, mouse and flat panel display will be available on the driver's aid boom and in the control room.

1.2 A keyboard will serve as the driver's aid pendant.

1.3 AD IO hardware will be Opto22 Pamux or B3000 brains, SNAP B-series IO rack, SNAP Analog and Digital IO modules.

Digital signals will be either 24 VDC or 5VDC

Analog signals will be +/- 10 VDC

2. <u>Logical Characteristics</u>

2.1 The Driver's Aid Program user interface will allow the driver to select scheduled tests. Through menu and drop-down list-box controls. Tests will be identified by an EPA assigned test number. This selection will provide the Driver's Aid with (a) information about the vehicle to be tested, (b) dynamometer test drive schedule, (c) the dynamometer test shift schedule and (d) the dynamometer test event schedule.

2.2 The Driver's Aid will accept pendant commands from the driver including, start vehicle or crank or key-start, vehicle start or start trace scrolling, pause trace, resume trace scrolling, abort test, engine stop or engine shutdown.

2.3 The Driver's Aid Program will provide with Driver with the vehicle speed versus time trace display for both target vehicle speed and actual vehicle speed.

2.4 The Driver's Aid Program will display a soak timer to the driver when appropriate.

2.5 The Driver's Aid will display messages to the driver

2.6 The Driver's Aid will display information about parts of the vehicle tests to the driver.

2.7 The Driver's Aid will provide audible alarms to the driver.

2.8 The Driver's Aid program will perform post-test trace analysis reports.

3. <u>IFC-DA Interaction and Interface</u>

3.1 The test site operator will execute an IFC-based pre-test setup process to ensure that the Driver's Aid computer has all necessary data files to conduct each vehicle test.

3.2 The test site operator will execute an IFC-based post-test process to archive Driver's Aid collected data files on LNS file servers and in relational databases.

4. <u>VDA-TDAP Interaction and Interface</u>

4.1 Ready for testing handshaking between the TDAP and driver's aid is accomplished with 24 VDC or 5VDC digital signals. The TDAP, upon initiation of a test, will look for a "ready for test" digital signal from the driver's aid. The TDAP may need to wait for the "ready for test" digital signal to appear. Once the "ready for test" digital signal is recognized, the TDAP may then send an "all systems are go" digital signal to the Driver's Aid. The TDAP will send the "all system are go" signal only after it has determined that all other instruments and systems necessary for the test are ready.

4.2 The dynamometer test event schedule identifies the time, relative to driver's trace time (or trace scroll time or drive time), at which key test-time events are to occur and the digital signals to be issued. An overview of the different time values and digital signals to be issued is available www.epa.gov/otaq/emisslab/methods/ftpevnts.jpg.

4.3 Key test-time events are accomplished with 24 VDC and 5VDC digital signals. Key test-time events signaled via digital signal to the TDAP by the driver's aid are defined in dynamometer event schedules or may be a consequence of the driver's aid sensing driver's pendant button pressing events. There will be one or more digital signals to identify the beginning and end of emission sample collection periods. Key events to be signaled include ready for test, collect emission sample, sample collection periods, soak, and abort test.

4.4 TDAP shall issue critical system status and critical alarm text messages to the driver via VDA per the following communication protocol. The TDAP will send the messages over the network in TCP/IP packets. The VDA will display the message (or data) in the Message window or otherwise as appropriate. That TDAP shall configure a TCP/IP socket with an EPA supplied IP address plus port number, open it and send a properly formatted TCP/IP packet with the message so that the DA will display the message. The contractor shall work with EPA to implement proper packet formatting and transmission.

Optionally, the vendor may include a remote color LCD message unit to be mounted on the EPA-provided VDA boom. This unit shall measure approximately *3" x 7"*, not to exceed *4" x 10"* and weigh less than *2 pounds*. The purpose of this display is to provide for simple text messaging from TDAP for communicating system status and critical alarms to the vehicle driver in place of issuing those messages via VDA.

For purposes of this contract this display function will be referred to as the Remote Message Display, or RMD, and shall be taken to mean either the issuing of text messages to the VDA or separate hardware display.

Appendix C

Interface Computer (IFC)

EPA shall provide the IFC. In 2002 the standard EPA IFC utilized the Windows NT 4.0 operating system. EPA-NVFEL expects, in 2003 through 2005 to complete migration away from the Windows NT 4.0 operating system to Windows 2000. Use of Windows XP, Linux/Unix and later version of Windows operating systems will be minimal. The IFC will adhere to the Appendix C1 NVFEL General Interface Guidelines and NVFEL Laboratory Network System requirements in Fixure xx except as described in the following sections.

1. Configuration

Pentium PC
Windows NT 4.0 or 2000

1.1 Software

Full installation of Microsoft Office 2000
Oracle Client Tools and Net 80

1.2 Communication Protocols

TPC/IP network protocol
NETBUI network protocol

1.3 Network Identification

Workgroup/Computer Name/Workgroup will be - IFC/SITE_D239 or IFC/SITE_D002 or IFC/SITE_DOO5

2.0 File Transfers Overview

Visual Basic File/Directory Commands will be used by IFC with TDAP. The contractor shall ensure that Visual Basic software, executing on the IFC, is able to control and supervise TDAP file and TDAP file-directory management utilizing disk drive, file directory and file management statements, summarized below.

The EPA IFC computer programs will utilize drive mounts or similar connections to enable Visual Basic applications to navigate directories and maintain files on the TDAP system disk drive. Example: NFS Software has been utilized at some NVFEL test sites with Unix OS TDAPs to satisfy this requirement.

Specific Visual Basic Statements to be utilized include:

- ChDir
- ChDrive
- RmDir
- Dir
- CurDir
- Kill
- Name
- FileCopy

3.0 TDAP/IFC During Testing Operation

Before Testing Operations - Visual Basic software running on the IFC files will control and supervise the transfer of files to established file directories on the TDAP. Such files will include configuration information, vehicle information and testing parameters necessary to conduct TDAP operations.

3.1 Test Time Operations - There shall be no TDAP requirements or dependencies for interaction with IFC and any LNS components during test time operations. TDAP shall be immune to LNS and IFC network traffic. An EPA-NVFEL network switch shall ensure isolation of the test site from non-test site network traffic.

3.2 After Testing Operations - Visual Basic software running on the IFC files will control and supervise the transfer of files from established file directories on the TDAP to the IFC and LNS computers. Visual Basic software running on the IFC files will control and supervise the cleanup of files and established file directories on the TDAP.

4.0 TDAP/IFC During Calibration and Maintenance Operations

During system instrumentation calibration and maintenance procedures - there shall be no interaction with the IFC and any LNS components.

After Calibration and Maintenance Procedures - Visual Basic software running on the IFC files will control and supervise the transfer of files from established file directories on the TDAP to the IFC and LNS computers. Visual Basic software running on the IFC files will control and supervise the cleanup of files and established file directories on the TDAP.

5.0 File Formats

Files shall be formatted according to the General Interface Guidelines in Appendix D.

Pretest variable names, formats and definitions

TDAP/IFC shall receive and utilize vehicle and other pre-test information from the Laboratory Network System.

Pre-test Formats
TDAP shall utilize variable names, formats and definitions as specified

Two formats are preferred

Format 1:

text file
no quote ‘”’ or comma ‘,’ characters allowed
lines terminated with carriage return <CR> and line feed <LF> characters
<CR> and <LF> at the end of lines are the only non-printing characters allowed
Each line contains
Value name
Space character <SP>
Equal sign ‘=’
Space character <SP>
Value string
text string | numeric code <SP> code text | numeric | numeric <SP> units

Example:
VariableName<SP>=<SP> value string <CR><LF>

TestNumber = 20020001278
Preferred Filename = “P_” & Format(TestNumber,”0000000000”) & “.txt”
= “P_20020001278.txt”

Sample File Content

TestNumber = 20020001278
MFR = 40 GENERAL MOTORS
VID = REPTRK/02
ConfigNumber = 2
ModelYear = 2001
ModelCode = 2 Truck
VehicleType = 04 Correlation
EngineType = 01 OTTO Spark
DriveCode = 1 Rear Drive Str Left
EngineCode =
ReqFuelType = 99 Other
TransCfgCode = 22 L5
TransMode =
AC = Y
FuelInj = Y
Turbo = N
EquivTestWt = 4750 lbm
CurbWt = 0 lbf
DrivAxleWt_F = 0 lbf
DrivAxleWt_E = 0 lbf
TireRimSizes = LT245/75R16
TirePSI_F = 0 psi
TirePSI_R = 50 psi
SideFan = 4 None
NmMainTnkCap = 26.0 gallon
NmAuxTnkCap = 0.0 gallon
DatabaseCode = C EPA LOD
SourceCode =
VIN =
EngineFamily =
EvapFamily =
Requester = BOCHENEK, DAVE
RequesterPh = 214-4595
TestPurpose = 11 Correlation
CertFlag = N
TestProcedur = 99 Other
TestType = Other
ShiftSched1 = FTA
ShiftSched2 = FTA

SIL =
VehicleVol = 0 ft^3
RFC =
AxleRatio = 0.00
IdleRPM = 0 rpm
IgnTiming = 0 deg
TimingRPM = 0 rpm
TargetCDT = 0.00 sec
ModelName =
NumCanisters = 0
CanWkCap = 0 gm
TotCanVol = 0.000 liter
EDynCoefSetA = 19.4 lbf
EDynCoefSetB = 0.056 lbf/mph
EDynCoefSetC = 0.03421 lbf/mph^2
EDynCoefTarA = 0.00 lbf
EDynCoefTarB = 0.000 lbf/mph
EDynCoefTarC = 0.00000 lbf/mph^2
ActDynHP = 13.3 hp
VehicleNo = 0
Transmission = auto
CanLoad = N
Evap = N
NumPreps = 0
Particulates = N
SchedComment =
VehOdoUnit = M
SH9 =
Emis_Bypass = N
SmpBag = Y
SmpDil = N
ZeroSpanByp = N
ZeroSpanCert = Y
CVSflowName = 350scfm

Format 2:
A text file bearing

<VariableName><TAB><value string><CR><LF>

Format 3: (Potential)
XML style format - negotiable
<?xml version=”1.0”>
<pretest>
<admin/
<variablename=”TestNumber” alias=”biddername” valuetext=”20040123001” numeric=”20040123001” units=””>
<variablename=”horsepowerat50” alias=”hpat50mph” valuetext=”14.5” numeric=”+1.450000E+01” units=”lbf”>
</pretest >

5.1 Post-test variable names, formats and definitions

The format of these files shall follow the general interface guidance in Appendix D.

The specific file format is negotiable, but must be approved, in advance by the EPA Project Officer.

.
5.2 Calibration and Maintenance variable name, formats and definitions

The format of these files shall follow the general interface guidance in Appendix D.

The specific file format is negotiable, but must be approved, in advance by the EPA Project Officer.

Appendix D

General Interface Guidelines

1.0 General Site Interface & File Formats

1.0.1 Network Requirements

The site computer system shall be compliant with EPA-NVFEL network requirements.

1.0.2 Communication Protocol

The site computer system shall be compliant with EPA-NVFEL communication protocol requirements.

1.0.3 File Transfer

All files created by the site computer system shall be transferable in a batch file selection and transfer mode. File transfers shall not be restricted to interactive file selection or to a single file transfer. All files shall be transferable via network interface and via removable storage media. File transfers shall not be restricted to proprietary methods or formats and shall use Commercial-Off-The-Shelf (COTS) software wherever possible.

1.0.4 File Format

Standard ASCII Formats (SAF) shall be used wherever available for files created by or sent to the site computer systems. Delimited ASCII Formats (DAF) shall be used for files created by or sent to the site computer system in all cases where SAF's are not available. For DAF's, the field names shall appear on the first line, data types shall appear on the second line, engineering units shall appear on the third line, and the field values shall appear on the fourth line and below. More specific DAF requirements appear in Sections 1.0.4.1 through 1.0.4.7.

1.0.4.1 The field names shall appear on the first line and the field types, engineering units values shall appear on lines two and below.

1.0.4.2 Dates shall be in "mm/dd/yyyy" formats. Time shall be in "hh:mm:ss" formats.

1.0.4.3 Real numbers, except for whole numbers, shall be in exponential (ñ.nnnnnnEñnn) formats.

1.0.4.4 Values that are not applicable for a particular field shall be filled in with a missing data code value of "-9.999E-99" for real numbers and "99" for characters.

1.0.4.5 Field names shall not contain embedded blanks; instead, underscores may be used to delimit.

1.04.6 Numeric data shall be right-justified and character data shall be left-justified.

1.0.4.7 The test report number shall follow the site computer naming convention. Export files containing data that synchronize with site computer data shall use the site computer test report number for identification.

1.0.5 Ease of File Editing and Installation

The site computer system shall be able to accept, validate, and use files that have been prepared or edited on external computer systems without further modifications. Installation of files shall be accomplished through a common user-friendly graphic interface rather than through cryptic installation procedures involving the typing of operating system commands or navigating through disk-drive, directory and file icons.

1.0.6 File Description

Information and format specifications for files that are created by or sent to the site computer system appear in Sections 1.0.6.1 to 1.0.6.15. For other files not described here, either SAF's or DAF's are required per Section 1.0.4.

1.0.6.1 Test Site Configuration Files

Test site configuration files shall identify the major site components in use, model information, software versions, and parameters that may be useful to emissions test site instrumentation, including the site computer system.

No standard format currently exists; therefore, either SAF's or DAF's are required per Section 1.0.4.

1.0.6.2 Dynamometer Configuration Files

Dynamometer configuration files shall identify the major dynamometer components in use, model information, software versions, and parameters that may be useful to other emissions site instrumentation, including the site computer systems.

No standard format currently exists; therefore, either SAF's or DAF's are required per Section 1.0.4.

1.0.6.3 Site Computer and Instrumentation system Configuration Files

Site and instrumentation system configuration files shall identify the major site and instrument components in use, model information, software versions, and parameters that may be useful to other emissions test site instrumentation.

No standard format currently exists; therefore, either SAF's of DAF's are required per Section 1.0.4.

1.0.6.4 Site and Instrumentation Options Selection and Control Parameters Files

Files that include the option selections (see Section 4.3.1.1) and any control parameters shall contain all user selections and all modifiable site/instrumentation parameters that control site performance aspects.

No standard format currently exists; therefore, either SAF's of DAF's are required per Section 1.0.4.

1.0.6.5 Test Sequence Control Schedules and Parameters Files

Test procedure control schedules shall contain driving schedule (trace) time versus analog/digital signal values (e.g., driver's pendant emulation). Test procedure parameters shall describe the test time events (e.g., startup and shutdown methods) corresponding to the analog/digital signal values.

No standard format currently exists; therefore, either SAF's of DAF's are required per Section 1.0.4.

1.0.6.6 Driving Schedule Files

Driving schedule files shall contain time versus speed values. The following driving schedules shall be useable with the site computer systems: UDDS; Hot-505 (first

505 seconds of the UDDS); HFEDS; NYCC; US06; SC03. Combinations of these driving schedules shall also be useable.

The format for driving schedule files shall be a single column of time in whole seconds and a corresponding single column of speed values expressed numerically in terms of miles per hour. A single, multiple-phase vehicle test shall require only one driving schedule file as opposed to one driving schedule file per sampled or not-sampled phase. All time and speed coordinates represent actual driving time and the first speed value shall be at t=0.0 seconds.

1.0.6.7 Shift Schedule Files

Shift schedule files shall contain either time versus gear values or speed versus gear values. Gear values may be represented by the gear number (i.e. 1 for first gear, 2 for second gear, etc.) or by a character (P for park, R for reverse, N for neutral, D for drive, etc.).

The format for shift schedules shall match the EPA shift schedule file format documented in the EPA Application for Certification Format Document. This format is SAF and includes schedule identification information, shift patterns, comments, and shifting point instructions corresponding to specific driving schedules. Shift points include driving schedule time (to the nearest tenth of a second), target shift speed (to the nearest tenth of a mph), and the shift action code.

1.0.6.8 Vehicle and Test Parameter Files

Vehicle and test parameter files shall include information necessary for vehicle identification and operation under test conditions. Vehicle identification shall include key database fields used to tag data files. Test parameter values may include inertia weight, dynamometer loading coefficients, target coast-down time, equivalent test weight, and dynamometer roll geometry (number of rolls per axle, number of axles to drive, and roll diameters).

No standard format currently exists; therefore, either SAF's of DAF's are required per Section 1.0.4.

1.0.6.9 Test Definition Files

Test description files shall include information necessary to select test descriptions, test sequence control and parameter, drive schedules, shift schedule, vehicle and test parameter files to be used in a single instance of a vehicle test. .

No standard format currently exists; therefore, either SAF's of DAF's are required per Section 1.0.4.

1.0.6.10 Mode Definition Files

Mode definition files shall describe the modes of a test description and shall identify the type, beginning trace time, duration in seconds, and ending trace time of each mode.

No standard format currently exists; therefore, either SAF's of DAF's are required per Section 1.0.4.

1.0.6.11 Acquired Hertz Data Files

Acquired Hertz data files contain recorded analog or digital values gathered at specific frequencies during tests. Data recorded at different frequencies will require separate files.

The format for acquired Hertz data files shall be DAF with one data field per column and corresponding field names in the first row.

1.0.6.12 Acquired Non-Hertz Data Files

Acquired non-Hertz data files contain data not recorded at steady frequencies during tests.

No standard format currently exists; therefore, either SAF's of DAF's are required per Section 1.0.4.

1.0.6.13 Input File Validation Reports

The site computer shall be able to accept, validate, and use files that have been prepared by external systems. If the file is not usable, the site computer shall generate a file validation report clearly identifying conflicts, as well as all formatting and content errors in the file.

No standard format currently exists; therefore, either SAF's of DAF's are required per Section 1.0.4.

1.0.6.14 Data Analysis Report Files

Test-time and post-test data analysis reports shall contain any analyses performed by the site computer on data collected during a test.

No standard format currently exists; therefore, either SAF's of DAF's are required per Section 1.0.4.

1.0.6.15 Event Log Files

All significant events shall be logged and time-stamped with clock time and trace time. Significant events include (but are not limited to) system power-up, reset, initiation and termination of setup and testing events, ready to test conditions, changes in ignition key positions, end of crank, engine start-up, engine shut-down, drive trace beginning and ending, control events (see Section 4.4.6.5), operator interventions, beginning and ending of trace idles, beginning and ending of soak periods, and the beginning and ending of emergency shutdowns and other safety events.

No standard format currently exists; therefore, either SAF's of DAF's are required per Section 1.0.4.

Appendix E

Dynamometer Data and Control Interface

The dynamometer will be provided under a separate contract, but integration with TDAP shall be included as part of the effort described in this Statement of Work.

1. Physical Characteristics

1.1 The Dynamometer computer will be the contractor's choice and will meet the interface requirements of the Interface Computer as described in Appendix C.

1.2 Dynamometer A/D I/O hardware will be the contractor's choice.
Digital signals will be either 24 VDC or 5VDC
Analog signals will be +/- 10 VDC
Optical Encoder Signal Availability:

1.3 The TDAP shall measure distance by counting dynamometer roll revolutions. The Dynamometer shall split each optical encoder pulse signal to two connectors that will make pulse signals available for (1) independent speed and distance determination by the TDAP or a customer data acquisition system, and (2) the dynamometer control system to perform its work. The pulse signals shall be a square wave 0-5 VDC. The TDAP or data acquisition systems using the connector shall be sufficiently isolated and conditioned so that connecting, using, and disconnecting from the pulse signal connector will not affect active use by the dynamometer control system.

1.4 The Dynamometer shall provide the each load cell signal to two connectors that will make the voltage signal available for (1) independent force determination by the TDAP or a customer data acquisition system, and (2) the dynamometer control system to perform its work. The load cell signals for the TDAP or customer data acquisition system will be ±10 VDC. The TDAP or data acquisition systems using connector shall be sufficiently isolated and conditioned so that connecting, using, and disconnecting from the voltage signal connector will not affect active use by the dynamometer control system.

2. Dynamometer-TDAP Interaction and Interface
The TDAP contractor shall coordinate with the Dynamometer contractor to ensure that requirements of this section are satisfied using Ethernet file exchanges, AK/Ethernet command protocol, SCPI/Ethernet command protocol, or digital/analog signaling as appropriate. Alternative to the digital/analog signaling methods, described below, must be approved by EPA.

2.1 At time of test the TDAP shall execute pre-test setup process to deliver pretest information to the dynamometer computer. Included with the pre-test information will be:

Vehicle ID
Vehicle Track Road Load ABC coefficients (pound-force, mph)
Dyno Simulation Road Load ABC Coefficients (pound-force, mph)
Equivalent Test Weight (pounds)
Test number
Test Date
Configuration (FWD/RWD/AWD)
Augmented braking (On/Off)
Dynamic Load Adjustment (On/Off)
Wheelbase (inches)

2.2 Immediately upon completion of a vehicle test TDAP shall execute post-test process to retrieve information to the dynamometer computer. Included with the post-test information will be:

Vehicle ID
Vehicle Track Road Load ABC coefficients (pound-force, mph)
Dyno Simulation Road Load ABC Coefficients (pound-force, mph)
Equivalent Test Weight (pounds)
Test number
Test Date
Configuration (FWD/RWD/AWD)
Augmented braking (On/Off)
Dynamic Load Adjustment (On/Off)
Wheelbase (inches)
Parasitic loss coefficients
HP@50
Simulated Inertia (pounds)
Total energy from vehicle per phase (Watts)
Total energy to vehicle per phase (Watts)

Positive energy simulation error (RMS%) per phase

Negative energy simulation error (RMS%) per phase
Total simulation error (RMS%) per phase

2.3 The TDAP contractor shall coordinate with the Dynamometer contractor to ensure that the TDAP and Dynamometer systems mutually achieve and appropriate and safe states of operation prior to allowing various modes of operation to begin. At the start of the test TDAP shall issue a test / reset command (bit=high) to the dynamometer. Nominally, dynamometer computer will then set a test-ready ready status indicator with 24 VDC or 5VDC digital signals. The TDAP, upon initiation of a test, and during the test monitors for the presence of the "ready for test" digital signal from the dynamometer. The TDAP may need to wait for the "ready for test" digital signal to appear. Once the "ready for test" digital signal is recognized, the TDAP may then proceed with test execution once it has determined that all other instruments and systems necessary for the test are ready.

2.4 The TDAP shall monitor and record all key test and dynamometer events. This shall be done, in part, with 24 VDC and 5VDC digital signals. Key test-time events indicated via digital signal to the TDAP by the dynamometer immediately before and during procedures include:

- Dyno in run mode - real time digital signal goes high only when the dynamometer is in run mode.
- Dynamic power adjustment on - real time digital signal goes high only when power reduction turns on. TDAP shall continuously record this status as part of the test data.
- Grade simulation active times - real time digital signal goes high only when road grade simulations are in effect. TDAP shall continuously record this status as part of the test data.
- Partitioning of procedures - At the completion of each phase the driver's aid will issue a phase reset command. At the end of the test sequence TDAP will change the test / reset command (bit=low)]
- Other signals may include abort test.
- Dynamometer shall issue critical system status and critical alarm signals to the TDAP. The TDAP will relay the appropriate text messages to the driver via the driver's aid per the communication protocol outlined in Appendix B.

Appendix F

Supplemental Requirements for Time-of-Operation Quality Monitoring and Reporting

All continuous and time of operation quality requirements for parameters monitored, measured and/or controlled by the system outlined in this Statement of Work in accordance with CFR requirements, shall be monitored against those CFR requirements, with additional modification and supplementation as found below.

Real-time sample proportionality within 2% of nominal for all sampling not accomplished via critical flow devices. Critical flow devices shall be monitored for maintenance of choke flow conditions.

Continuous Exhaust BackPressure within +/- 1.0 inches WC of atmospheric pressure (2.0 inches WC for US06) as measured at 20 Hz, filtered at the approximate equivalent of 1.5-second averaging

Distance Driven per test phase within

FTP Phase 1	3.537 and 3.645 miles
FTP Phase 2	3.801 and 3.956 miles
FTP Phase 3	3.537 and 3.645 miles
HFET	10.140 and 10.366 miles
US06	To be specified
REPCA Phase 1	Nominal ± 0.25%
REPCA Phase 2	Nominal ± 0.25%

Phase (Sample) Time within 3 seconds of nominal

Subsystem Status OK

Diluent Concentrations (Ambient Air)

HC	2.4 to 6.9 PPM (carbon)
CO_2	0.030% to 0.050%
CH_4	1.6 to 2.7 PPM
NO_x	0.0 to 0.8 PPM
CO	0.0 to 2.5 PPM

Diluent Concentration (BMD Diluent Air Bag Sample)

HC	0 to 100 PPB (carbon)
CO2	0 to 50 PPB
CH4	0 to 100 PPB
NOx	0 to 100 PPB
CO	0 to 200 PPB

Sample readings within 105% of calibrated range of analyzer

Sample readings within 20 minutes of sample completion

Zero/span results ok

Continuous Specific humidity between 35 and 55 grains/pound

Continuous temperature between 70 and 82 degrees F

Dyno Simulation Error per test phase (limit tbd)

Leak checks performed and passed within last 15 clock hours from start of test

System calibration and traceability status "OK" as defined by time interval and successful completion of calibration procedure

All pre-test information sent to the dynamometer controller shall be received back at the end of the test. TDAP shall verify that the post-test information is the same as the pre-test information.

<u>Post-test Quality Control Report</u>

The Post-Test Quality Control report shall report on all time of test quality monitoring results tailored for the specific test performed. At a minimum the report shall include a header that contains the following information.

1. Test number
2. Date of test
3. Start time of test
4. End time of test
5. Vehicle ID
6. EPA test site designation
7. Test type

8. Limit table designation

Beneath the report header shall be a statement of the quality monitoring result, as appropriate. The statements shall include the following or similar wording:

> "All automatically monitored quality requirements were met".

Or

> "Warning, this test did not meet certain automatically monitored quality requirements, as indicated by flags below:"

Operator-entered Quality Control Report remarks shall appear directly beneath the quality summary statement.

The report shall include a summary of the minimum, maximum, average and pass/fail conditions for the following parameters as relevant for the specific test configuration:

1. Ambient cell temperature (during all sample and soak periods)
2. Ambient cell humidity (during sample periods)
3. Exhaust backpressure
4. All heated component temperatures as required by the CFR citations
5. Filter face temperature
6. Secondary dilution tunnel dilution air temperature
7. All sample proportionality statistics as required by the CFR and citations or this Statement of Work
8. Bag mini-diluter dilution ratio
9. Sample analysis times

The report shall also include the following:

1. Indication as to whether the CVS remained in choke flow during the test
2. Indication as to whether required leak checks had been performed in the last 15 hours
3. All system warnings issued during the test
4. Distances traveled for each phase were within required limits
5. Dynamometer Simulation Error per phase
6. Sample phase times within required limits
7. Ambient dilution air concentrations of HC, NOx, CO2, CO, Methane were within limits

8. BMD dilution air air concentrations of HC, NOx, CO2, CO, Methane were within limits

9. All bag analysis times were less than 1200 seconds
10. All zero and span checks were within limits
11. Sample concentrations of CO2 were within reasonableness limits
12. All measurements were made in the calibrated range of the device
13. All instrument zero span measurements and corrections
14. Other contractor-recommended parameters, including those made significant by the design and functioning of the measurement system

For parameters listed in the minimum, maximum and average condition section, the system shall provide for separate limits for instantaneous and average levels. Instantaneous values may filtered or averaged, if required, to provide a more representative assessment. The contractor shall specify all signals, which are filtered or averaged in association with this monitoring function, in their system documentation.

Statutory limits shall be utilized in the monitoring function where applicable, unless other limits are specified in this Statement of Work. Where monitored parameters are not governed by statutory limit, the contractor shall propose limits based on engineering judgement relevant to the influence of the parameter on the test outcome. All limits shall be stored in separate tables or files. The tables shall be easily modifiable within the set functions available at the highest security level.

The associated Limit Table shall be stored and printable as part of the post test Quality Control Report, in accordance with ISO standards.

Appendix G
Vehicle Test Reports

The nominal vehicle test report shall have a structure and layout in keeping with the sample on the following 2 pages:

NVFEL Laboratory Test Data

Preminiary Dynamometer Test Results

Test Information

Test Number:	2002-nnnn-nnn	Vehicle ID:	SAMPLE
Test Date:	10/4/02	MFR Name	nnn
Key Start:	17:14:00	MFR Code:	nnn
Dyno Number:	Dnnn	Config #:	00
Operator:	nnnnn	Transmission:	manual
Fuel Type:	6	Shift Schedule:	FT5
Test Procedure:	95	Odometer:	000000.0
Calculation Method:	Gasoline	Drive Schedule:	SC03
Pretest Remarks:			

Quality Control: QC Exceptions Identified

Bag Data

		THC (ppmC)	CO (ppm)	NOx (ppm)	CO2 (%)	CH4 (ppm)	NonMeth HC (ppmC)
Phase 1	Sample	11.338	2.972	1.504	0.390	5.360	5.533
	Ambient	3.586	0.000	0.000	0.039	1.829	1.605
	Net Concentration	7.856	2.972	1.504	0.352	3.584	4.273
	Remarks:						
Phase 2	Sample	8.847	2.477	1.400	0.391	5.234	3.178
	Ambient	3.736	0.000	0.000	0.038	1.804	1.782
	Net Concentration	5.220	2.477	1.400	0.354	3.483	1.737
	Remarks:						
Phase 3	Sample	8.621	0.893	1.556	0.393	5.510	2.654
	Ambient	3.586	0.000	0.000	0.038	1.829	1.605
	Net Concentration	5.140	0.893	1.556	0.356	3.734	1.406
	Remarks:						
Phase 4	Sample	0.000	0.000	0.000	0.000	0.000	0.000
	Ambient	0.000	0.000	0.000	0.000	0.000	0.000
	Net Concentration	0.000	0.000	0.000	0.000	0.000	0.000
	Remarks:						

Results

	THC (gpm)	CO (gpm)	Nox (gpm)	CO2 (gpm)	CH4 (gpm)	NMHC (gpm)	Vol MPG (mpg)
Phase 1	0.263	0.201	0.190	374.0	0.139	0.143	23.76
Phase 2	0.173	0.166	0.175	372.6	0.134	0.058	23.87
Phase 3	0.170	0.060	0.194	373.4	0.143	0.046	23.83
Phase 4	0.000	0.000	0.000	0.0	0.000	0.000	0.00
Composite	0.2019	0.1419	0.1864	373.35	0.1384	0.0822	

Fuel Economy

	Gasoline MPG
Phase 1	23.64
Phase 2	23.75
Phase 3	23.71
Phase 4	0.00
Composite	23.72

Dyno Settings

DynoSet A:	
DynoSet B:	
DynoSetC:	
Simulated Inertia:	
DriveTire PSI:	35
Fuel Container ID:	F00077

Page 1 of 2 Print Time 10-Oct-2002 16:08

NVFEL Laboratory Test Data

Premiminary Dynamometer Test Results

Test Number: 2002-nnnn-nnn   Vehicle ID: SAMPLE

Phase Mass Results	THC	CO	NOx	CO2	CH4	NonMeth HC	Meth Response
	(grams)	(grams)	(grams)	(grams)	(grams)	(grams)	1.083
Phase 1	0.928	0.708	0.670	1319.0	0.489	0.504	
Phase 2	0.615	0.590	0.623	1324.1	0.475	0.205	
Phase 3	0.606	0.212	0.692	1331.2	0.509	0.166	
Phase 4	0.000	0.000	0.000	0.0	0.000	0.000	

Test Conditions	Phase 1	Phase 2	Phase 3	Phase 4	
Avg Barometer (inHg)	28.58	28.57	28.56		
Avg Cell Temp (degF)	*92.8*	*93.1*	*92.4*		Limits Exceeded
Avg Dew Point (degF)	*65.8*	*66.3*	*65.9*		Limits Exceeded
Specific Humidity (grains/lbm)	99.99	101.82	100.42		
NOx Corr Factor	1.1331	1.1442	1.1357		
CVS-Bag Dilution Factor	34.20	34.14	33.99		
Vmix (scf @68F)	7229.62	7219.44	7217.30		
Avg CVS Flow Rate (SCFM)	721.76	720.74	720.53		
Dilution Air Volume (scf @68F)					
Obseved Dilution Factor (vol/vol)					
Phase Time (sec)	601.00	601.00	601.00		
Distance (miles)	3.527	3.553	3.565		

Data Quality Flags

QC Exceptions Identified - See flagged data and Quality Control Report

Page 2 of 2   Print Time 10-Oct-2002 16:08

The results for other measured or calculated results, such as particulate matter, formaldehyde, ethanol etc shall appear on supplementary pages, and shall include all pertinent data such as concentrations , pre and post-test weights, flow volumes, etc.

For hybrid type vehicles with regenerative braking, the following additional factors shall be reported for each test phase and summed for the entire test :

Charge Balance(%)
State of Charge (%)
Regenerative Capture Efficiency(%)

The Charge Balance and State of Charge are both an indicator of whether there was a net transfer of energy from the battery, or to the battery in a hybrid electric vehicle. Energy shall be measured in watts. Depending on the result of a pre-test query, either a voltage constant, or actual, real-time measured voltage, shall be used in these calculations. Regenerative Capture Efficiency is a measure of how well the hybrid drive train is able to absorb kinetic energy during braking. The factors shall be calculated as follows:

Charge Balance = ((Total Energy from hybrid drive battery - Total Energy to hybrid drive battery) / Total energy absorbed by the dynamometer from vehicle per phase) * 100

State of Charge = ((Total Energy from hybrid drive battery - Total Energy to hybrid drive battery) / Total fuel energy) * 100

Regenerative Capture Efficiency = Σ Current to hybrid drive battery * Open circuit voltage (or real time voltage, if pre-selected) / Total energy from the dynamometer to the vehicle per phase * 100

Where,

Total Energy from hybrid drive battery = Σ Current from hybrid drive battery * Open circuit voltage (or real time voltage, if pre-selected)

Total Energy to hybrid drive battery = Σ Current from hybrid drive battery * Open circuit voltage (or real time voltage, if pre-selected)

Fuel energy = fuel consumed * fuel energy factor

For carbon based fuels: fuel consumed = carbon balance fuel consumed (gallons)
For hydrogen fuel: fuel consumed = mass fuel flow meter total (kg)

The fuel energy factor will be contained in the Pre-Test Information File

The report shall indicate whether open circuit voltage or real time voltage was used in energy calculations.